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THE PERFECT CIRCLE Rumor Page

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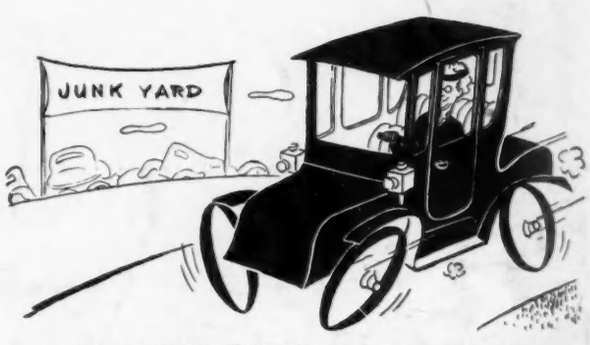
**Contributed by George L. Glaser, 2839 Sunset Pl., Los Angeles 5, Calif.*



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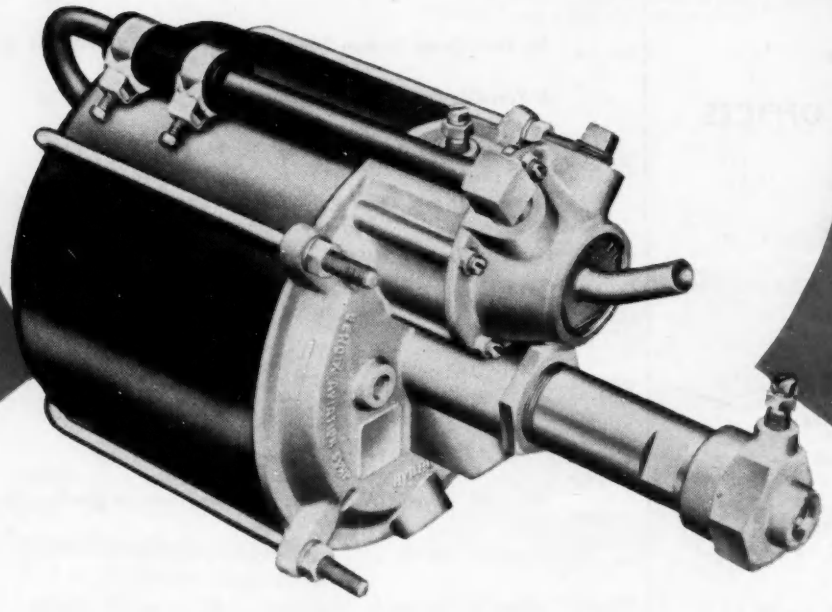

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BASED ON PAPER* BY

Max M. Roensch

Research Coordinator,
ETHYL CORP

HIGH COMPRESSION

Engine Performance

PRELIMINARY tests with the experimental high-compression engine, built by General Motors Research Laboratories Division, confirms theoretical expectations that compression ratios of engines can be increased to better efficiency.

The test engine which contributed to high compression knowledge, as shown by charts accompanying this article, is one of a number of experimental V-8 engines being built for oil company laboratories for fuel research work. Basically this engine is built around the Oldsmobile V-8 cylinder block, which has a 3 3/4-in. bore. A special crankshaft with a 3 1/4-in. stroke gives a piston displacement of 287 cu in.

There are two reasons for this special crankshaft. First, it was desired to keep the power at the higher compression ratios down within the general range of the standard engines. Second, it permitted use of standard production connecting rods in combination with a stronger piston.

At 12 to 1 compression ratio the firing pressures are much higher than they are in the present production engine. This was taken care of in the case of the piston by adding 3/32 in. to the piston crown and by providing heavier ribs between crown and pin bosses. The standard production connecting rod is given a special heat treat to get the required strength.

Three sets of cylinder heads are provided to give compression ratios of 8, 10, and 12 to 1. The three compression ratios permit testing of fuels ranging in octane number from the present regular and premium fuels on the 8 to 1 ratio to fuels having an octane number of 100 or better on the 12 to 1 ratio.

Since this engine is built to withstand loads imposed by the high pressures accompanying high compression ratio, it makes an excellent means of determining the effect of compression ratio on engine efficiency.

For these tests to be valuable to the automotive engineer, they were run on the dynamometer using the complete engine installed in the car . . . complete in every respect with intake silencer, fan, water pump, generator, muffler, and exhaust system. With performance data in this form, it is simple to translate the dynamometer information into road performance or miles per gallon, as well as to show the effect of compression ratio on brake specific fuel consumption, with all the normal parasitic losses automatically accounted for.

It should be understood that to obtain these data, the engine was operated as a representative production passenger car engine, using a production carburetor that had been developed for a production car. The same gasoline was used for all these tests and was of high antiknock quality to permit maximum spark advance on even the 12 to 1 compression ratio.

Test data derived with this engine, shown by the charts which follow, indicate the three most fruitful paths toward engines of higher efficiency as being:

1. A thorough and careful examination of the engine and all its components with the aim of reducing friction of the "as installed" engine.

2. The creation and use of designs that will permit an increase in compression ratio as fuels become available.

3. A real effort to obtain more effective use of the heat now wasted in the exhaust. →

* Paper "Thermal Efficiency and Mechanical Losses of Automotive Engines," was presented at SAE National Passenger Car, Body, and Production Meeting, Detroit, March 10, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

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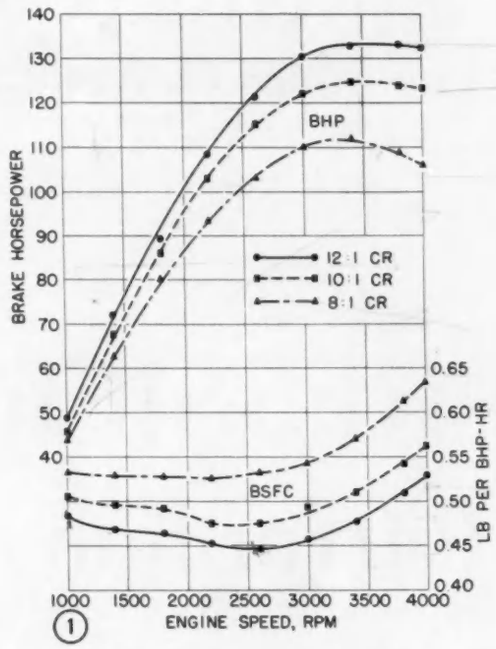


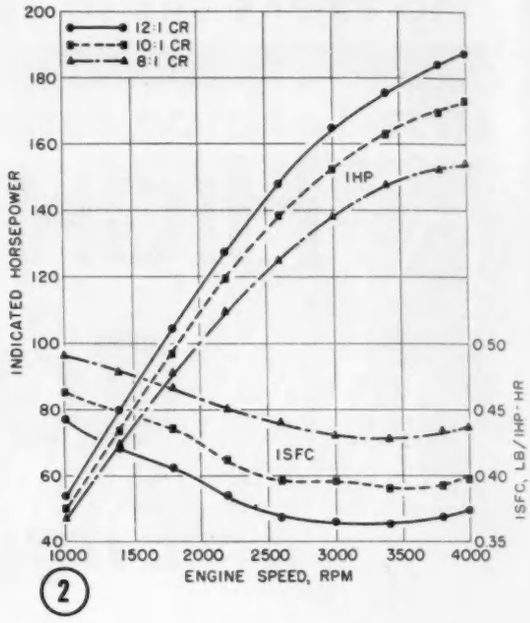
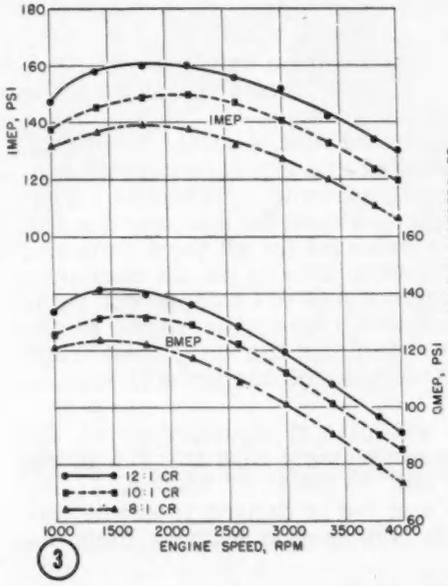


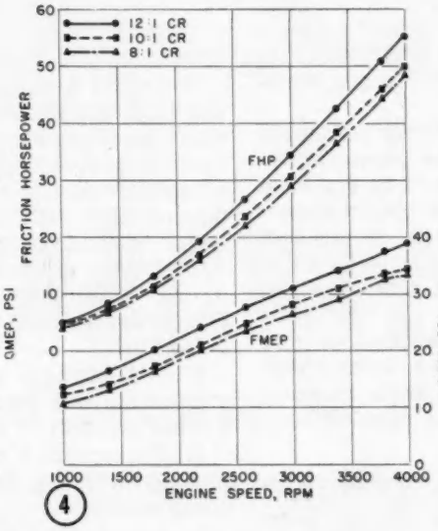
Chart 1 shows the brake horsepower and brake specific fuel consumption of this experimental engine with the three compression ratios. Note that the response of this engine to an increase in compression ratio is excellent—in accord with theoretical expectations. This shows there are no abnormal internal friction losses accompanying increase in compression ratio, as frequently happens when compression ratios are raised.

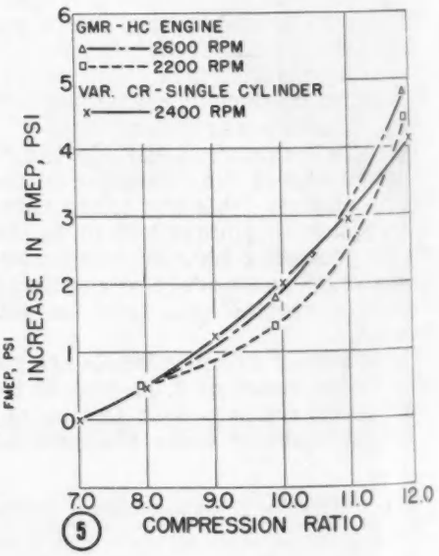
If the compression ratio of an engine is increased without reducing volumetric efficiency and there is no increase in output, the difficulty may be due to internal friction losses.

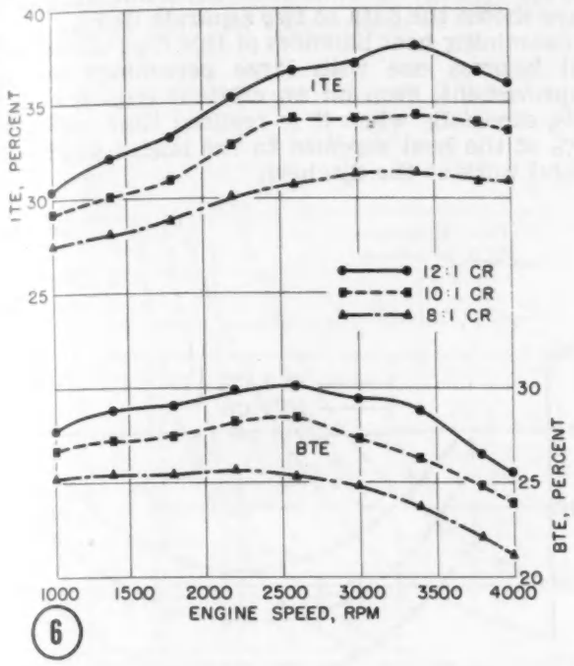
Chart 2 shows the indicated horsepower and indicated specific fuel consumption. Changes on an indicated basis also meet with expectations, and the mechanical efficiency remained constant at the three ratios tested.

Indicated and brake mean effective pressures are shown in Chart 3. The friction horsepower in Chart 4 is interesting because it demonstrates clearly that as compression ratio is increased, friction horsepower also increases. This confirms information obtained on our single-cylinder engine, where effect of compression ratio on motoring friction was carefully evaluated at compression ratios from 7 to 1 to 12 to 1, as shown in Chart 5.









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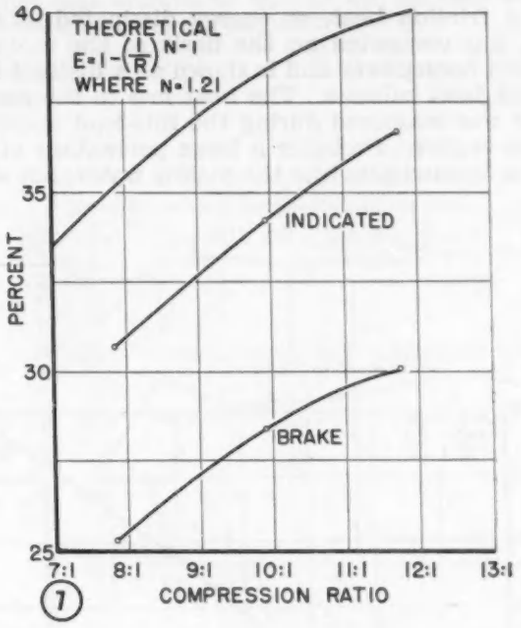

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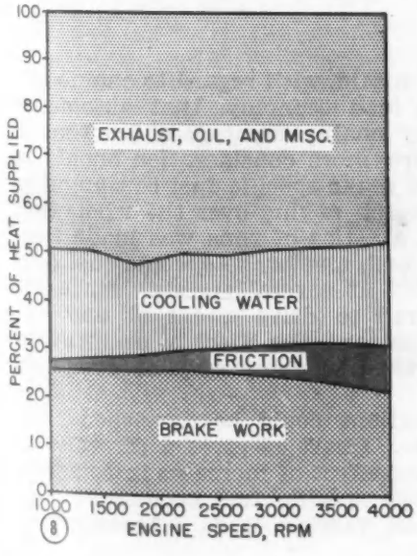
How increases in compression ratio affects both the indicated thermal efficiency and brake thermal efficinecy of this engine shows up in Chart 6. Improvement in efficiency with increased compression ratio is consistent over the whole speed range. Chart 7 compares the brake and indicated thermal efficiency plotted against compression ratio at an engine speed of 2600 rpm. The improvement in both indicated and brake thermal efficiency over the whole range from 8 to 12 to 1 compression ratio is excellent.

Fact that the percent improvement in indicated thermal efficiency is the same as would be expected on a theoretical basis gives excellent proof that there is no fundamental reason why compression ratios could not be increased to improve efficiency, as soon as fuels are available to permit such a change.

To compare the overall engine performance at the three compression ratios, heat balances have been prepared for the complete engine and are shown in Charts 8, 9, and 10, for compression ratios of 8, 10, and 12 to 1, respectively. These data were obtained by converting the actual observed data on power, friction, and heat rejection to the coolant into the percentage of heat represented by each portion and



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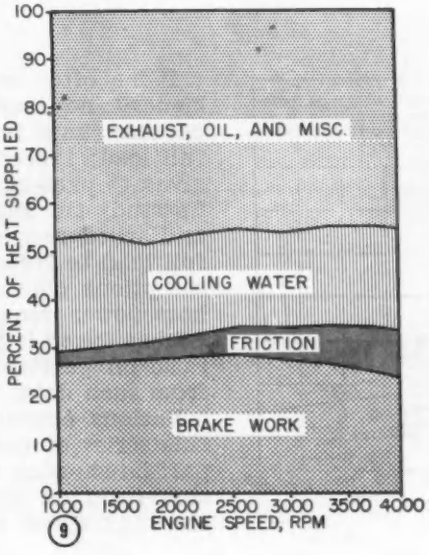

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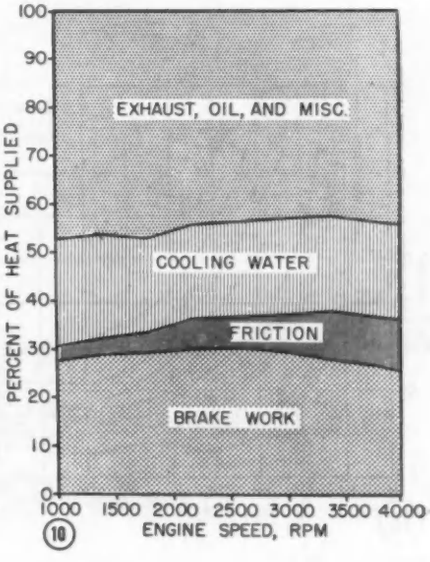

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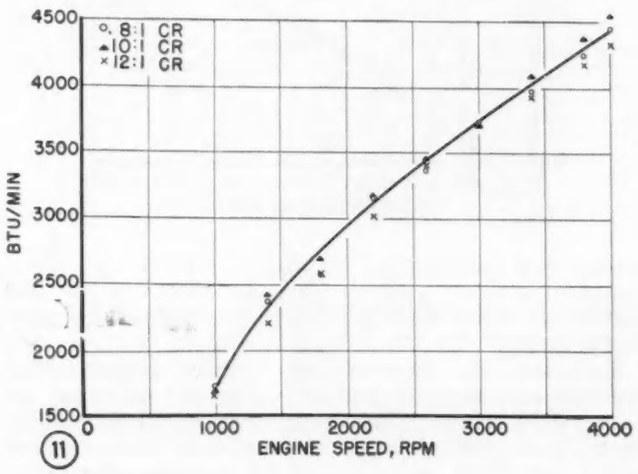
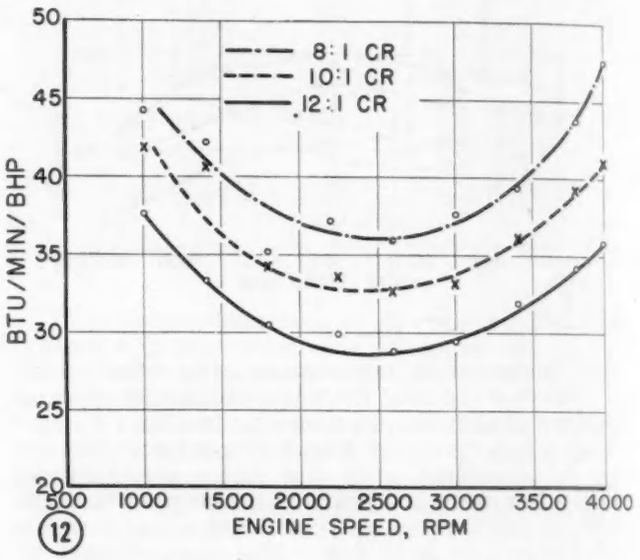
charging the balance to exhaust and radiation losses.

The friction heat, or energy dissipated as friction, was computed on the basis of the motoring friction horsepower and is shown as a distinct item in this heat balance. The heat loss to the cooling water was measured during the full-load operation of the engine. Probably a large percentage of the engine friction goes into the cooling water; but since the percentage of loss to the cooling water that should be attributed to friction is not known, we have shown the data as two separate items.

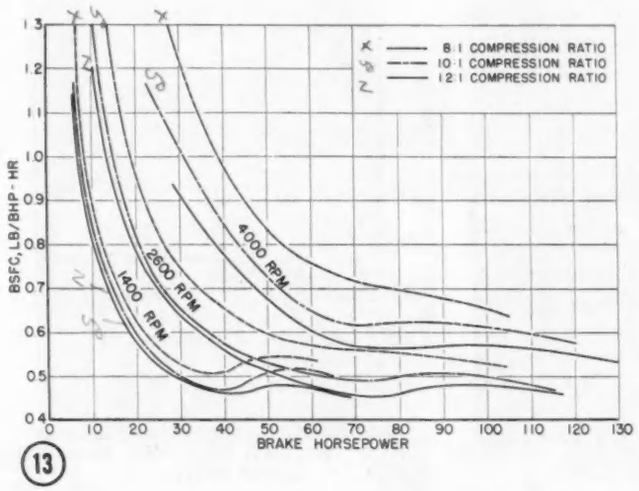
Examining heat balances of this type cannot help but impress one with large percentage left for improvement, even on an efficient engine such as this, especially when it is realized that only 25 to 30% of the heat supplied to the engine appears as useful work at the flywheel.





Another useful comparison that can be drawn from the work to date on this experimental V-8 engine is the effect of compression ratio on heat loss to the cooling water. Chart 11 shows the heat loss at the three ratios in Btu per min over the entire speed range. These data would indicate that when no other changes are made, there is little difference in heat loss to the cooling water on a Btu per min basis.

But if the data are analyzed on the basis of Btu per min per brake horsepower, as shown in Chart 12, there is a noticeable reduction in Btu per horsepower per min as compression ratio is increased.

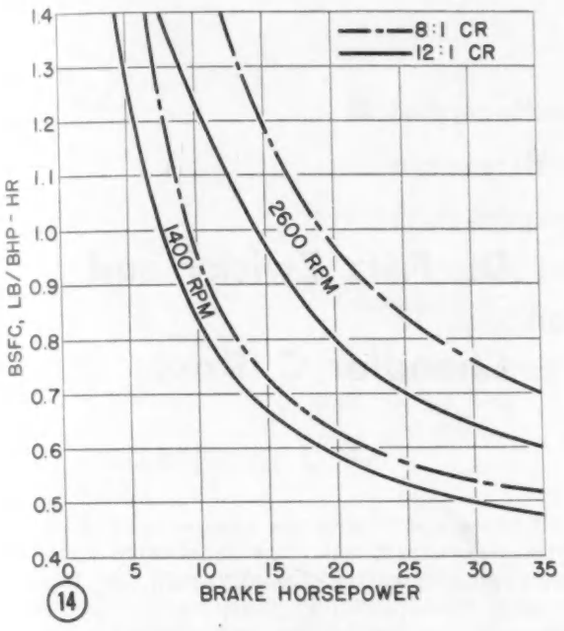


It has often been said, with regard to engine efficiency and road load economy, that automotive engines run a very small percentage of the time at full load; therefore, more consideration should be given to part-load brake specific fuel consumption. To study the research engine over the whole load and speed range, a series of runs was made from full load to 10% load, and brake specific fuel consumptions obtained at several speeds. Since the horsepower required to drive a car at any one vehicle speed is constant, the effect of compression ratio on part-throttle economy may be computed from such data.

Various combinations could be developed from this series of tests. Chart 13 gives a direct comparison showing the effect of increases in compression ratio on brake specific fuel consumption at constant speed and varying loads. According to

these data, if the compression ratio is increased with no other change, there will be an improvement in brake specific fuel consumption throughout the entire engine load and speed range.

The carburetor setting was not changed for this comparison and the vacuum advance on the distributor was allowed to change the ignition timing in the normal manner at part throttle.



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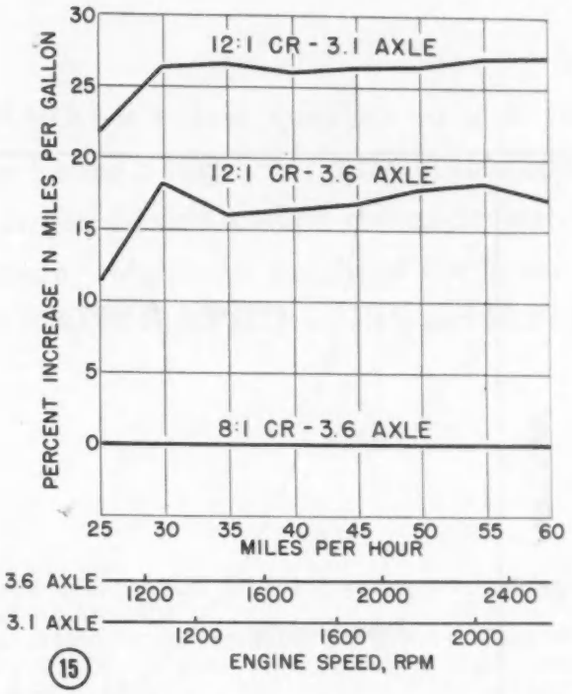
To make a better comparison of the effect of compression ratio on brake specific fuel consumption at the lighter loads and moderate speeds, a portion of the data from Chart 13 is replotted to a larger scale and shown in Chart 14. Preliminary investigations on this engine at the three ratios show that the maximum power air-fuel ratio is constant at full throttle. Thus all the gain in economy at full load must come from an improvement in efficiency.

Data such as these in Chart 14 may be used to show the effect of compression ratio on fuel consumption of a car operating on a level road at constant speed. The results of a study of this nature are shown in Chart 15. Here the improvement in gasoline mileage of the 12 to 1 compression ratio over the 8 to 1 is given, computed on the basis of both the constant axle ratio and with the axle ratio reduced to give the same high-gear acceleration with the 12 to 1 ratio as with the 8 to 1 ratio heads.



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Nitromethane Excels

BASED ON PAPER* BY

Dr. Fritz Zwicky and
Director of Research

Chandler C. Ross
Chief Engineer, Liquid
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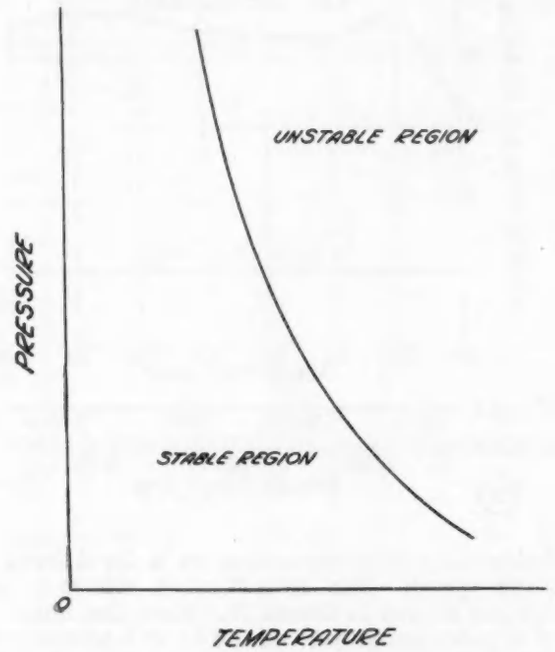

Fig. 1—Properties of an ideal monopropellant

All these good handling characteristics of nitromethane contrast with the sensitivity, high vapor pressures, corrosivity, toxicity, and fire hazard of the oxidizers commonly used in bipropellant systems. But performance characteristics are comparable. And as a monopropellant, nitromethane may cut down complexity of mechanical circuits.

Nitromethane approaches the ideally tempera-

EASE of handling makes nitromethane a more attractive rocket propellant than common bipropellant combinations.

Nitromethane is a monopropellant containing all the constituents in the proper ratio for heat release at high-explosive rates. Yet nitromethane will not decompose under temperature and pressure conditions likely to be met. What's more, tests show that nitromethane is relatively insensitive to shock—although the point has been argued vigorously by rocket specialists.

Containers, lines, and fittings for nitromethane present no special problems. Corrosion is negligible. Low vapor pressure and low viscosity simplify pumping.

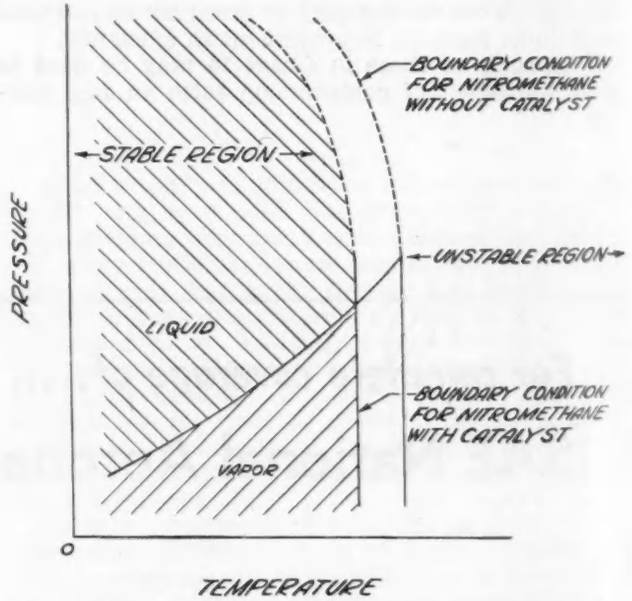

Fig. 2—Pressure-temperature diagram for nitromethane

* Paper "Nitromethane as a Monopropellant" was presented at SAE National Aeronautic and Air Transport Meeting, New York, April 11, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

as Rocket Propellant

■ **Nitromethane (CH_3NO_2) is a clear, colorless liquid of the nitroparaffin group, having a slight, not disagreeable odor. It decomposes to carbon dioxide, carbon monoxide, water, nitrogen, and hydrogen. Molecular weight of the liquid is 61; specific weight is 70.96 lb per cu ft at 70 F and 68.07 lb per cu ft at 130 F.**

ture-and-pressure-insensitive monopropellant represented in Fig. 1. On this pressure-temperature curve, the boundary between stability and instability is clearly defined. This ideal fluid is completely stable under all combinations of temperature and pressure left of the curve. Right of the curve, the fluid is increasingly unstable as temperature and pressure mount.

Catalyst Reduces Stability

Actually, nitromethane follows the temperature-pressure diagram in Fig. 2. It requires addition of 1 to 2% catalyst to decompose smoothly in the rocket chamber. The catalyst reduces the stability slightly, as the left boundary curve indicates. At least up to 1500-psi pressure, stability is essentially independent of pressure. Higher pressure ranges have not been investigated.

At atmospheric pressure, boiling point of nitromethane is 220F and decomposition temperature is around 500F. This spread in temperatures makes for handling safety. Even if temperature of nitromethane rises to 220F and continues to climb, most of the vaporized nitromethane will escape before reaching decomposition temperature, unless the fluid is confined very tightly.

Just as important as nitromethane's temperature and pressure insensitivity is its demonstrated shock insensitivity. These observations indicate that under normal circumstances nitromethane is extremely shock stable:

1. Nitromethane in thin-walled containers will not detonate when initiation is attempted with a No. 8 blasting cap.

2. Nitromethane in heavy-walled containers will not detonate upon striking the ground with an estimated deceleration of 900 g after being dropped from an airplane.

3. Nitromethane confined in heavy-walled containers will detonate when initiated with liberal charges of tetryl or other high-order explosives.

In the third case, there is a question whether shock alone or a combination of shock and local heating initiated decomposition.

Whether or not a shock will initiate decomposition depends on condition of confinement and severity of shock. Two types of explosion can result in nitromethane: complete detonation of high order, possibly propagated through all lines and fittings in the system; and localized, low-order decomposition of a small quantity within the bulk. High-order detonation has been produced only in experimental testing where the test sample was subjected to particularly severe conditions. There is a wealth of statistical evidence to show that none of the mishaps which can occur in rocket powerplants impose the extreme conditions necessary to initiate a complete detonation.

Of course, shock sensitivity is difficult to evaluate. Some rocket researchers have rated nitromethane dangerously shock sensitive. More evidence gathered from more development experience with actual engines will settle the question.

Corrosion Rates Low

Nitromethane attacks commonly used stainless steel and aluminum alloys at rates less than 0.0001 in. per year and mild steel at only about 0.0005 in. per year. Most other common metals and alloys are attacked at rates too low to cause structural failure. Plastics such as bakelite, chlorinated rubber, and polyethylene resist completely.

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Table 1—Calculated Performance Characteristics of Propellants

Propellants	Chamber Pressure, psi	Mixture Ratio, oxide/fuel	Exhaust Velocity, fps	Specific Impulse, sec	Density Impulse, sec	Chamber Temperature, F	Mean Mol. Wt., lb per mol	Specific Heat Ratio
Nitromethane	300		7010	218	248	3980	20	1.25
Hydrogen Peroxide (100% pure)	300		4700	145	212	1790	23	1.25
Hydrogen Peroxide (10% water)	300		4250	131	186	1360	22	1.25
Liquid Oxygen—Gasoline	300	2.5	7780	242	236	5470	22.7	1.22
Liquid Oxygen—100% Ethyl Alcohol	300	1.5	7810	243	235	5250		
Liquid Oxygen—Ammonia	300	1.4	8220	255	249	4951		
Liquid Oxygen—Hydrazine	300	.33	7920	246	256	3232		
Liquid Oxygen—Liquid Hydrogen	300	.33	11050	358	101	4290		
Liquid Oxygen—15% Ethyl Alcohol, 25% Water	300	1.3	7700	239	237	5080	22	1.22
Red Fuming Nitric Acid—Aniline	300	3.0	7090	221	307	5020	25	1.22
White Fuming Nitric Acid—Furfuryl Alcohol	300	1.9	6890	214	293	5020		
Hydrogen Peroxide—Hydrazine Hydrate	350			200		2690	24.0	1.2

Nitromethane's physical properties are favorable for pumping. Vapor pressure is 0.57 psi at 70F and 2.74 psi at 130F. Viscosity is 1.36×10^{-5} lb per sec per sq ft at 70F and 0.951×10^{-5} lb per sec per sq ft at 130F.

All three of the oxidizers in general use for bipropellant combinations—liquid oxygen, nitric acid, and hydrogen peroxide—are hard to handle.

Liquid oxygen boils at – 297F at atmospheric pressures, so it must be kept in specially insulated, cold containers. Even then, evaporation is inevitable. Low storage temperatures limit choice of container materials. High vapor pressures at ambient temperatures complicate pumping.

In contact with the skin, liquid oxygen produces effects similar to severe burns.

Nitric acid can be stored in stainless steel containers, but is highly corrosive to other metals. It emits toxic fumes and burns skin severely.

Dangers of Hydrogen Peroxide

Hydrogen peroxide decomposes explosively in contact with impurities such as those present in dirty containers or pipes or with moderate heating. Exposing a container of hydrogen peroxide to sunlight has caused explosion. Concentrations of hydrogen peroxide above 87% may be exploded by gunfire.

Besides, hydrogen peroxide is a fire hazard. It can initiate combustion of cellulose materials. Leaky containers have started fires during transport, and supposedly empty containers have ignited wooden floors.

All three bipropellant oxidizers are potential fire hazards in crashes where they may contact their fuels, with which they are spontaneously combustible. All three are more corrosive than nitromethane.

Nitromethane Performs Well

While the major features of nitromethane as a rocket propellant are its stability, noncorrosivity, and pumping characteristics, it can give good performance with the simpler plumbing characteristic of the monopropellant system. Development of nitromethane rocket powerplants and components is only beginning, but performance characteristics have been calculated. They appear in Table I with characteristics of hydrogen peroxide as a monopropellant and of common bipropellant combinations. Nitromethane's specific impulse of 218 sec is within the 200-255-sec range of those for bipropellants, excluding liquid oxygen-liquid hydrogen, and considerably above ratings for hydrogen peroxide as a monopropellant.

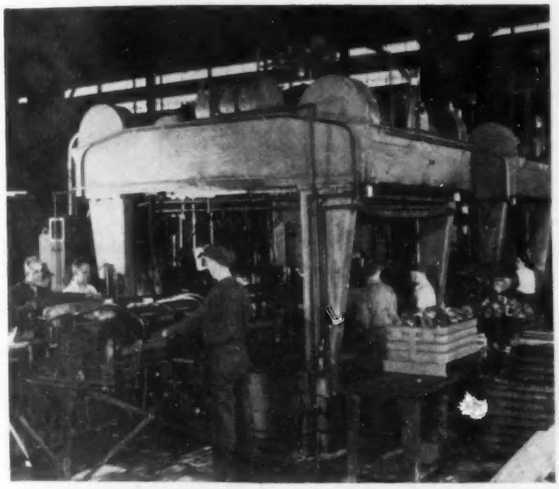
Density impulse tells a similar story. (Density impulse is the product of specific impulse and specific gravity. Impulse per unit volume is significant because it affects size and weight of the propulsion system.)

If past trends in propellant selection continue, nitromethane's favorable chemical and physical properties will outweigh any small penalties in specific or density impulse.

PRODUCTION Welding

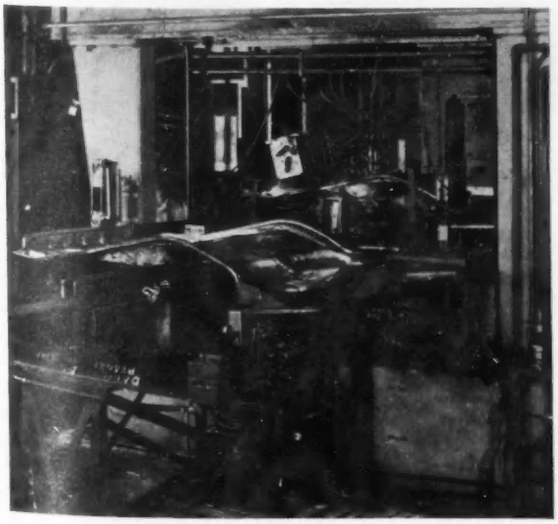
Press-Welder Hookup

How 300 completely assembled floor pans are stamped and welded per hour, each with about 100 welds, a total of some 30,000 welds per hour or 500 a minute



ABOVE: multiple transformer press welders and stamping presses for rear floor pan of the 1949 Ford. Three presses (one easily visible) are hooked up in series with two multiple transformer type welders. Blank is moved from first stamping press to end of line automatically

BELOW: Closeup of exit end of floor pan line, with pan elevated into welding position in the last machine. Note hydraulic guns with electrodes in contact with work. At left is three-phase electronic panel which controls the welding current



BASED ON PAPER* by

John F. Randall

Welding Development Engineer
Ford Motor Co.

NEWLY developed high-speed multiple transformer resistance welders have speeded welded automotive assemblies at minimum cost, because these machines produce weldments as fast as stamping presses work—and permit a straight line flow of the material from the blank to the finished major component.

Today's average automobile body has more than 8000 spot and projection welds. An automotive body plant, to produce 5000 bodies a day, must make 40,000,000 resistance welds in 24 hr.

A definite trend in automobile frames is toward arc and resistance welding instead of riveting. Newer frames have 600 in. of arc welding, and about 170 resistance welds. Usually 450 of the 600 in. of arc welding is done automatically, and 150 in. is applied by hand.

To produce 5000 frames a day, 250,000 ft or 47½ miles of arc welding, and 850,000 resistance welds are required every 24 hr.

Sixteen welded valve push rods are needed for an eight cylinder engine, or 80,000 of these welds for a 5000-a-day engine schedule.

To cope with this huge volume of welds per day, some modern high-speed welding equipment produces 300 or more automotive assemblies an hour with each assembly containing from 100 to 300 resistance welds.

Components in the smooth flowing layout of press-welding equipment consist of:

- A four post rapid action press with bottom platten movable.
- Guide rails, or a conveyor, passing through the press to support or move the part.
- Contoured fixture with copper backup electrodes is mounted on the lower press platen.
- Small resistance welding transfers usually mounted on the stationary upper press platen.
- Many hydraulically operated welding guns attached to the transformer secondaries.
- A hydraulic pressure system.
- Electric welding control panel.

Three different secondary circuit arrangements

* Paper "Welding Applications in Automotive Construction" was presented at SAE Metropolitan Section, Jan. 20, 1949. (This paper is available in full in mimeographed form from SAE Special Publications Department. Price, 25¢ to members, 50¢ to nonmembers.)

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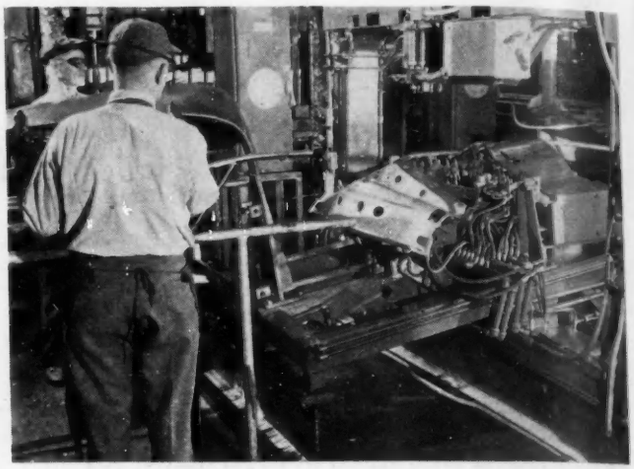
are used for making spot or projection welds in multiple transformer press type welders.

A single welding machine may have up to 30 transformers, each of which can produce four spot welds when used with a series circuit.

Normal operation sequence of a multiple transformer type resistance welding machine is:

- Blank is moved to proper position in the press on rails or conveyor. This is usually done mechanically and automatically.
- The bottom platen of the press rises, pressing the part against the proper backup electrode, bringing it in contact with the hydraulic guns. Then the electronic panel energizes the transformers and the welds are completed.
- Platten then drops, returning the part to the rails or conveyor.
- The next part moves into the welding position as the welded part moves out of the opposite side of the press.

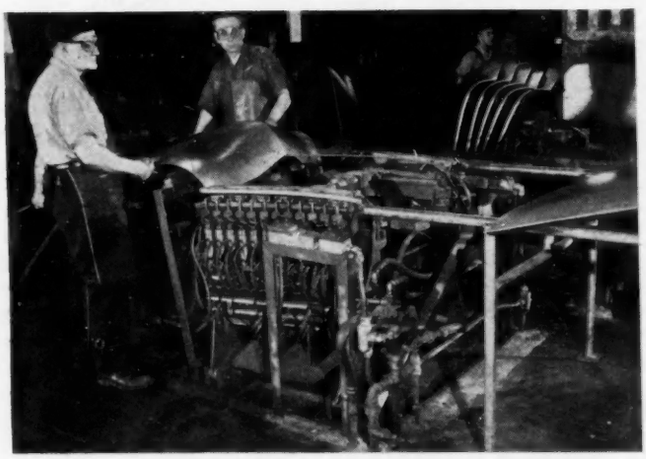


ABOVE: Second welder attaches inner hood panel to front flange and top of outer panel. Inner panel in place and will be moved upward and forward when 20 welds will be made. Machine has five transformers. Note the transformer and four guns above inner panel at upper right

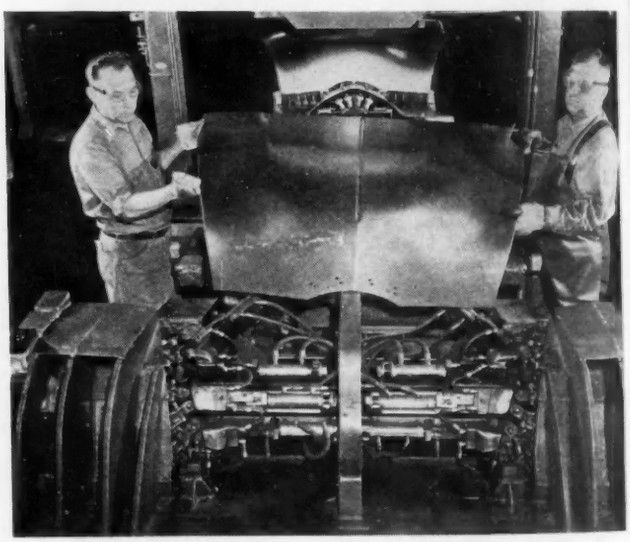
How to Weld 360 Hoods an Hour

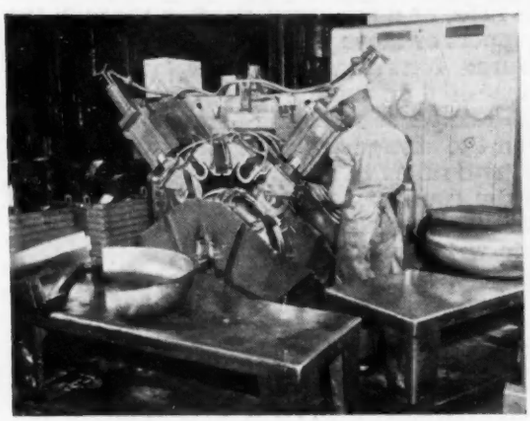
Here three multiple purpose transformer welders in series with each other, but without presses hooked up, make 56 welds on hood panels, a total of 20,160 welds on the 360 hoods per hour.

BELOW: First welder in the series attaches side reinforcing channels to side flange of hood panel. Here 24 welds are made, using six transformers. Channel is in place over backup electrodes



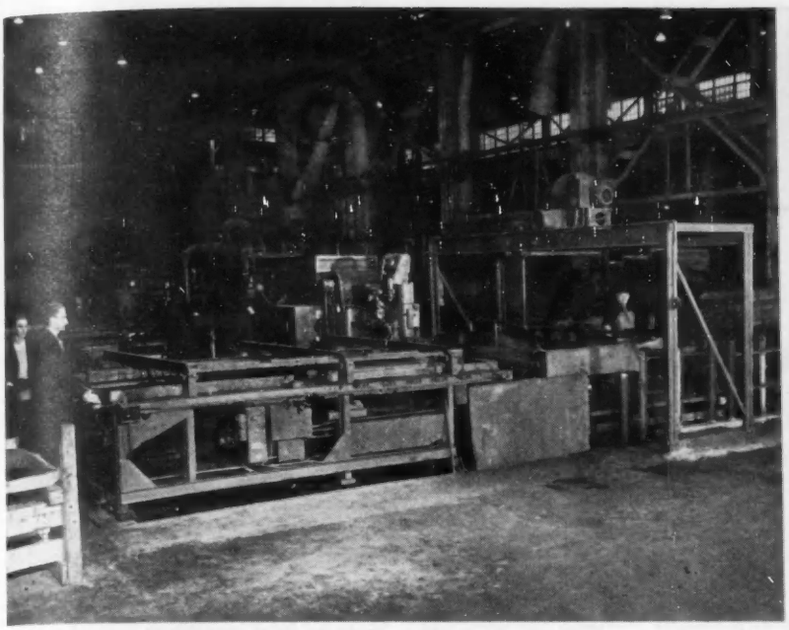
BELOW: Final machine connects inner and outer panels at the sides, and through three thicknesses of outer panel, inner panel, and side reinforcements. Makes eight series and four direct welds with five transformers

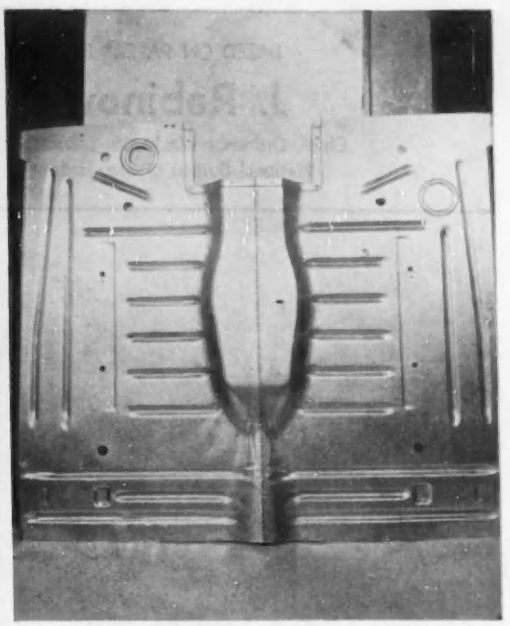




Continuous Flow Welding

LEFT: Double head resistance seam welder to join two halves of Ford wheel housing seen in front of machine at lower left. Two welding wheels located at outside edge of halves are backed by solid copper bar at inner side of joint. Current passes through one wheel, down through work, into backup bar, under second wheel, up through the work and into second wheel and back into other side of transformer. Produces 48 in. watertight joint in each housing in 5 sec. The two wheels produce the weld at the rate of 580 ft per min. There is no offtime, operation being continuous and production rate is 180 housings with their 8640 in. of weld per hour



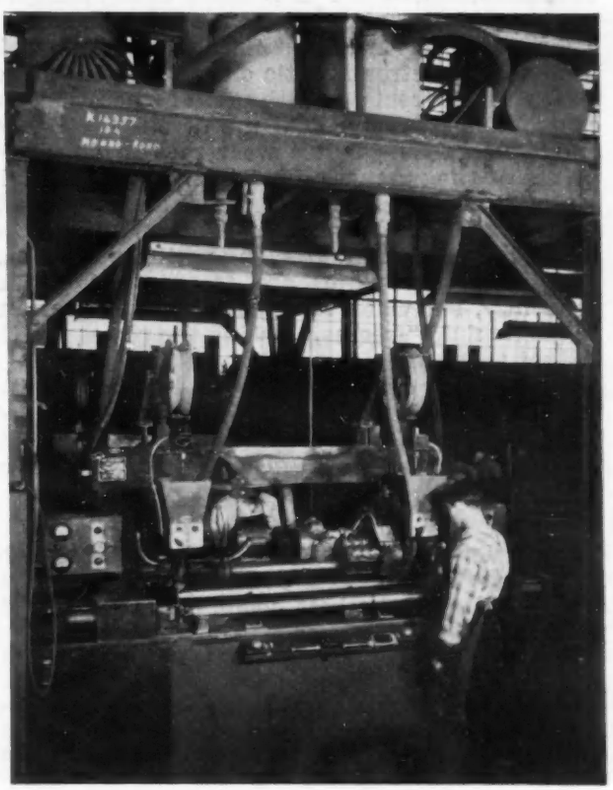


This Seam Welder . . . . . Welds this Front Floor Pan

LEFT: Minimum manpower is required on this high speed pan seam welder which produces 300 of the pans an hour, each with about 460 in. of ½ in. lap weld. A Z-bar is used, no pre-tacking or pre-assembly being required. Only three men required. Two at left lift two sheets on conveyor which moves them into welding wheels. Overlap is automatically attained

RIGHT: Floor pan formed. Note that weld is subjected to severe forming stress. Despite deep draw, scrap from weld failures is held to only a fraction of 1%

RIGHT: Welder which welds yoke to tube at rate of 250 per hour, with actual welding time of 7½ sec each. Fixture in front of machine presses yoke into shaft, which then rolls down under welding heads. Shaft is then lifted vertically and into contact with rolling drive roll (center of illustration) when the wire feeds down, flux is released, arc starts, and tube rotates until weld is completed—all automatically. Tube then rolls out of machine



BELOW: Submerged arc welded yoke and drive shaft tube, with yoke pressed about ½ in. into tube

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BASED ON PAPER* BY

J. Rabinow

Chief, Ordnance Mechanics Laboratory
National Bureau of Standards

MAGNETIC

Adaptable to

(This paper will be printed in full in SAE Quarterly Transactions.)

A FLUID having the unique property that its viscosity is externally controllable by means of a magnetic field has been developed at the Bureau of Standards.

The fluid consists of finely powdered iron dispersed in a suspension medium, usually oil. In the normal, unmagnetized condition, the iron is distributed at random in the oil, but when the mixture is subjected to a magnetic field, the iron particles become magnetized, are attracted to each other, and bind themselves together, with the result that the viscosity of the mixture increases. If a strong enough magnetic field is used, the mixture becomes almost solid.

First application of this fluid at the Bureau has been to an electromagnetic clutch, built to demonstrate the extreme smoothness of operation, easy controllability, economical use of electrical power, and seemingly negligible wear rate made possible by use of the magnetic fluid in such a device. Essentially the clutch consists of two steel plates—the driving and the driven members—with the fluid sealed between them. As long as there is no magnetic field, the plates are free to rotate independently, but when the current is turned on, the magnetic fluid "freezes," locking the plates together so that they rotate as a unit.

With further development work, it is foreseen that this fluid will also be adaptable to other control devices, such as a filler for dashpots, to replace the valves of a hydraulic system, and in shock absorbers.

The Fluid

In its development of this fluid, the Bureau has found that both oil and powder must be carefully selected to give the best combination of desirable properties.

Specifically, the suspension medium must meet the following specifications:

- It must be stable and not decompose over the range of operating temperatures, which may be down to –70 F or up to 450 F.
- It must have a high flash point, a high fire point, a high viscosity index, and its vapor pressure should be negligible.
- Its viscosity must be tailored to fit each application.
- It must not corrode the iron powder.
- It must not exhibit catalytic action with the powder.
- It should be capable, either by itself or in combination with some additive, of maintaining an equilibrium suspension of the powder.

In addition, the powder must meet certain specifications, such as the following:

- It must have high magnetic permeability and the particle size must be the best compromise between the fineness necessary for the particles to stay in suspension and the size necessary to provide optimum magnetic properties.
- It must cause the minimum amount of abrasion.
- It must have a high curie point.

Suspension Medium

Of the many fluids tried, the ones that seem best able to meet the exacting requirements are:

- Silicone oils.
- Chlorinated diphenyl.
- Chlorinated polyphenyls.
- Organic phosphates.
- Chlorinated benzene.
- Chlorinated diphenyl ethers.
- Chlorinated petroleums.
- Hexachlorobutadiene (a new nonflammable hydraulic fluid).

* Paper "Magnetic-Fluid Control Devices," was presented at the SAE National Transportation Meeting, Cleveland, March 28, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

FLUID

Many Control Devices

All these fluids are extremely temperature stable, some of them being capable of operation up to 800 F. Most of them have a high viscosity index, and all have low vapor pressure. Their viscosity at 25 C is in the range of 5 to 150 centistokes.

Viscosity may be low or high, depending on the application. For instance, it is desirable that clutches in servomechanisms transmit a minimum torque when the clutch is de-energized, so a low-viscosity fluid is needed. Conversely, when a clutch is to operate a torque-limiting device, it is necessary only that the viscosity be low enough to afford slippage at the minimum torque required.

Corrosion of the iron particles will occur unless the fluid is free from sulfur and similar impurities.

The problem of the settling out or sedimentation of the iron in the oil has been attacked from several angles:

1. It is possible to minimize this action by using some very heavy, viscous grease as the suspension medium. For some devices, this is an acceptable method; however, in clutches and similar devices, where it is desired that the torque transfer during the declutching periods be at an absolute minimum, the viscous drag of heavy grease is sometimes prohibitive.

2. A more acceptable solution generally is to produce a mixture in which the particles are thoroughly wetted with a liquid of quite low surface tension. In this type of mixture, settling takes place at a very rapid rate but the particles are surrounded by a thin film of fluid, so that redispersion takes place easily.

3. Another possibility is the production of a thixotropic mixture—a mixture that is in a gel-like condition that easily supports the iron particles during inoperative or static periods, but that has a sharp drop in viscosity as soon as shearing of the mixture takes place. Thus, when the clutch is inoperative, even for long periods of time, the particles remain in suspension, but as soon as the clutch is operated, shearing takes place and the mixture becomes extremely thin and fluid. When operation of the clutch ceases, the fluid again thickens.

4. Another method of maintaining suspension of particles that shows considerable promise is the maintenance of a low-flux-density, steady-state magnetic field during inoperative periods. This is, of course, not necessary during operation, since the turbulence created by the rotating members is sufficient to maintain dispersion.

Magnetic Powder

Materials that have already been tested for the powder (given in degrees of decreasing permeability) are:

- Hydrogen-reduced iron.
- Hypo-eutectoid steels.
- Eutectic steels.
- Hyper-eutectoid steels.
- Iron-molybdenum and carbon steels.
- Ferroxcubes.

Although hydrogen-reduced iron might seem the best choice because it has the highest permeability, it is not satisfactory because it corrodes rapidly in the presence of oxygen and moisture, with a resulting drop in magnetic efficiency. Another difficulty is its tendency toward catalytic action with most oils, causing a complete loss in fluidity.

Most successful so far is grade E carbonyl iron powder, which is a hypo-eutectoid steel. It consists of tiny spheres having an average particle diameter of 8 microns, or 0.0003 in.

The spherical shape, it is believed, may contribute to smoothness of engagement and minimization of abrasion and wear of moving members.

The magnetic characteristics of this powder are essentially unchanged up to its curie point of approximately 785 C, provided only that it is protected from oxidation.

The ferroxcubes have been found to be completely unsuccessful for a number of reasons: permeability is extremely low and curie point is low, that is, they cease to exhibit magnetic properties at 165 F, so that they are practically useless in devices where energy is being transformed into heat.

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Technical Highlights

Part II

(Part I appeared in the May Issue)

Bumper and Grilles

Massiveness characterizes most bumpers and bumper guards. The Cadillac rear bumpers form a continuation of the rear fender portions above it. The rear license light is inserted centrally and within it. The Buick front bumpers are made to harmonize with the general grille design. The rear bumper ends are designed to form a protective encompassing cap for the back of each rear fender. The ends are reinforced below by back bars fastened directly to the frame, which are hidden by shields occupying the space between the rear of the body and the upper edge of the bumper. The license plate holders consist of a recessed center portion in each bumper. Oldsmobile, always bumper conscious, provides dual rear bumper guards with built-in license plate lights. The license plate bracket is no longer placed on the trunk lid of any GM cars. Packard has two front horizontal bumper bars duplicating the motif of the two long horizontal grille bars above them, presenting a truly unified design. Plymouth and Dodge bumpers have a ridged cross-section, while DeSoto has an accentuated top bead. Wrap-around bumpers are universal, front and rear, except in the case of the Cadillac and Buick rear bumpers, whose protective side length is limited. Rear fenders are sometimes recessed to permit closer nesting of the wrap-around ends, as in the case of Oldsmobile and Chrysler.

The motif of most grilles consists of horizontal lines, usually three, interrupted by minor vertical dividers. The center bar either terminates in a parking light at each side or two bars encompass it. Buick, DeSoto, and Mercury still cling to emphasis on vertical lines. The Buick grille is made up of three sections, consisting of a frame and a right and left grille body, which includes the vertical grille bars. It has been made wider to give an increased air intake. The frame reaches out to the vertical centerline of the headlight, which point was formerly occupied by the parking light, now atop the fender, and blending into a molding extending back to the front doors. Lincoln has the widest grille with its 4-bar outwardly sloping and tapering design extending the full front width and encompassing the parking lights. Mercury portrays functional design, since the chromium grille symbolizes air streamers entering the surrounding shell or "air tunnel." Ford shows a bold open design, the lack of vertical spacers being pleasingly offset by a large center medallion. The Chevrolet grille bars are extended inward and upward to direct the flow of air and hide the radiator core, horns, and other behind-the-grille parts. Reflections on these surfaces from behind are eliminated by an Argent silver paint finish. The parking lights are built into the inside radius of each end of the upper bar. The Packard Custom body is decorated across the rear above the stone guard by two ornamental chrome parallel horizontal bars terminating at each side in the tail lamp combination, with a small center strip and vertical bars simulating the front grille.

Sheet Metal

Fenders are becoming less conspicuous in the new styling, in being visually absorbed by surrounding contours. The fender metal itself, being the part that covers the wheel, has greater proportions than before, especially at the front. In the Nash Airflyte, the front wheels are enclosed by the sheet metal, with the elimination of the usual fender cut-out, the narrower axle tread (54 11/16 in. from 57 ½) and increased width (77½ in. from 74½ on the "600" and 75⅜ in. on the Ambassador) permitting full wheel lock. Is the wheel, the greatest of all inventions, surely, to the automotive minded, a motif worth preserving or shall it be hidden, as in the case of rear wheels? To those willing to emulate it, it is being better framed by an opening closer to a true circle. Over 10 years ago when front fenders had not fully grown to proper height, the otherwise true arc was replaced at the top of the opening by a cord, truely a perversion. Last year's Oldsmobile

# of Postwar Automobiles

By
Austin M. Wolf
AUTOMOTIVE CONSULTANT

Futuramic pioneered the way back to the deserved true relationship between wheel and fender cutout.

To simplify the servicing of front fenders on the Chrysler-built cars, they are made in two pieces, the joint being covered by a chrome molding extending back from a short distance from the headlight bezel, back into the front door, and at a level slightly below the light center. When the Packard Clipper came out in 1941 with an integral rear quarter body panel and fender, little was it realized that it was the forerunner of today's vogue. Only the Chrysler-built cars, Studebaker, Buick, Cadillac, and the Oldsmobile "98" have separate fenders. In the Chevrolet-Pontiac-Oldsmobile body the integral fenders may be reached from the luggage compartment for repair bumping. In the front it can be reached by removing the rear seat cushion and in some cases the quarter panel trim. In the center, opposite the wheelhouse, the outer fender surface can be reached by unbolting a panel in the outer side of the wheelhouse. In damage where the fenders are distorted, Ford recommends the use of hydraulic or pneumatic jack equipment and hand tools that match the fender contours by skilled workers, and is conducting a school for them. Replacement of a large portion of the rear fender is done by cutting off the damaged area with an arc welder. A matching portion of a new fender is similarly cut and the new material welded in place. This is aided by the vertical seam running back along the top edge of the fender panel, where it joins the rear deck sheet from the end of the drip molding. In the Chrysler-built cars, the rear fenders, with their down and slightly rearward slope at the forward end, project but slightly and are assembled to the outside of the luggage compartment by five hex-head bolts, which go into self-locking nuts and to the body by eight hex-head bolts and clinch nuts.

Buick provides chrome-trimmed embossed port holes along the upper side portion of the front fender, three on each for the series "50" and four on the "70." They assist in the ventilation of the engine compartment. A single-section chrome fender molding extends horizontally the full length of the car, protecting fenders and sides of the body from dents and scratches. The Cadillac "61" and "62" have moldings extending from the front wheel opening across the fender apron and front door; a molding across the rear fender is aligned horizontally with the front one and a chrome stone shield is located below it at the front. The series "62" has a stone shield at the back of the front fender wheel opening for visual balance effect rather than protection. The leading edge of most rear fenders is protected by a shield of stainless steel. Since the Chevrolet fender baffles, located just back of the front wheels, are directly exposed to stones thrown from the tires, a protective coating is applied over the paint on the front surface to prevent its chipping and also to deaden the noise. The gasoline tank filler cap is located in a sealed compartment covered by a door in the left rear fender. In the Nash, a molding runs along both "fenders" at the top of diminutive wheel cutouts and around the body, front and rear. The Lincoln Cosmopolitan has a wide projecting molding along the front fender only, with no protection to the body, whereas the Lincoln has a continuous molding, front to rear. The Ford and Mercury moldings run the length of the side. The Ford rear fender flat panel area is pleasantly broken by the reversed streamlined tail light contour. The Oldsmobile "98", Buick, and Cadillac continue the rear fender backward in fin fashion, apart from the body and rear deck, giving a long sweeping effect. The Cadillac "dorsal fin" terminates at its vertical center, the rear half being contoured by the tail light and a reflector button is located at its base. The left button, when pressed, unlatches the hinged tail light unit and uncovers the gasoline tank filler spout. The Chevrolet rear fender crown is highlighted by a stainless-steel molding 5/8 in. wide, purely decorative, extending from the body sill at the front to the gravel deflector at the rear. The front fender of the Chrysler-built cars sweeps into the front door panel but not as prominently as before, in view of the wider body. Mercury carries back its fender line

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with a downward slope into the body in the form of a raised panel with a rounded top edge. Just ahead of the back edge of the front door in the four door sedan, it drops with an S curve to a horizontal level just above the car length molding and carries back to the rear trunk where it forms a curve concentric with the trunk contour. The raised rear fender panel is thus established.

Most hoods continue back to the base of the windshield, which is permitted by the elimination of the cowl ventilator. The Chevrolet hood is made in two pieces, riveted together, but appearing as a single panel, due to a center molding covering the joint and painted the same color as the hood. Packard and Buick continue with the one-piece hood resting on selective side hinges.

Bodies

Chevrolet, Pontiac, and the Oldsmobile "76" and "88" are equipped with the same body shells in two types, one with a streamlined back and the other with a trunk back, and known as the GM "A" body. The streamlined side rear window back edge slopes forward instead of continuing downwardly on a curve. On the 4-door models the front contour of the rear fender is part of the the rear door. The Chrysler-built cars are equipped with the trunk-back type of body to preserve headroom above the rear seat. The Oldsmobile "98" and the Buick series "50" and "70" utilize the same body shells, known as the GM "C" body.

In the Chevrolet design 53% of the total weight is supported by the front wheels, compared with 51% in the previous model. With a 6-passenger load, 35% of the passenger weight comes on the front wheels as compared with slightly more than 30% in the previous design. Total weight with a 6-passenger load results in the weight being almost equally divided, front and rear. The rear seat was moved forward more than 7 in., the front seat slightly over 4½ in., the engine 3 in. and, with 1-in. shorter wheelbase, the engine is now 4 in. farther ahead of the centerline of the front wheels.

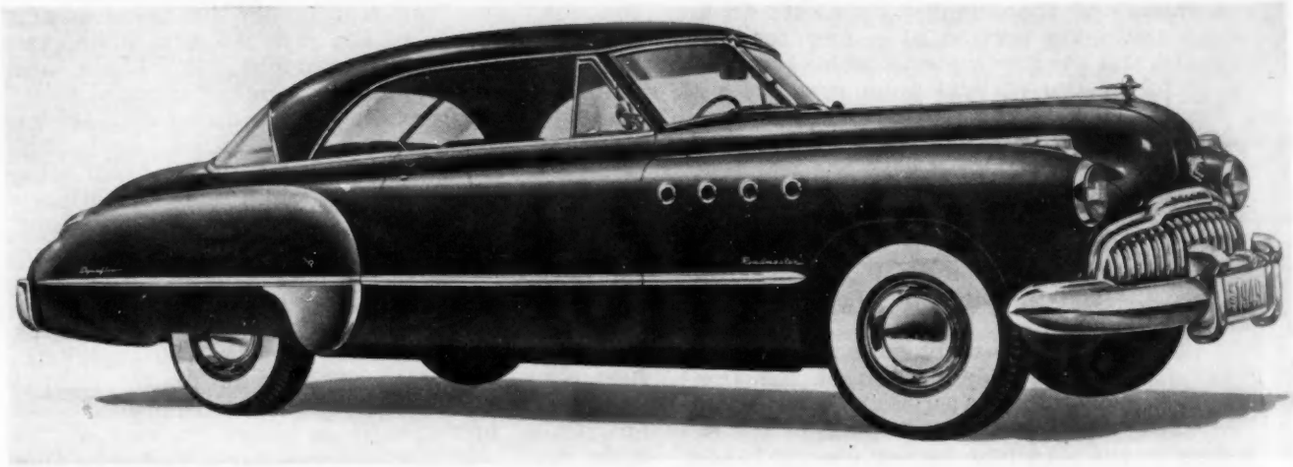
The Willys all-steel station wagon was introduced in July of 1946 and initiated a movement away from the stereotyped wooden body. The embossed "posts and rails" are painted a natural wood color and the panels brown. In 1948 Packard introduced its all-metal construction station wagon, including the top. The second of the two full side seats "disappears" into the floor and the back of the front seat, affording nearly 9 ft of useful length. Decorative hardwood trim is used on the outside exterior of the doors, window panels, and tailgate. Ford and Mercury in the 1949 models followed this all-steel construction and wood trim. Chevrolet has two station wagons, the all-steel one using decalcomanias to simulate wood grain, protected by three coats of gloss synthetic lacquer. The wooden construction has a hard top and the lower body panels connecting the fenders are separate steel stampings attached to the body.

A dynamic appearance is imparted to General Motors and Chrysler-built cars by a decided downward slope of the belt line molding starting at the windshield pillar. Plymouth uses a concave chrome molding for highlighting effect.

The hard-top "convertible" has taken a strong hold. One of the best examples is seen in the Buick Riviera (Fig. 13), with its rear window of wide curved glass that extends around the rear corners of the car and occupies part of the area normally covered by the rear quarter panels. The large window has a vertical chrome dividing strip at each side, separating the center large-radius light from each side small-radius pane. It is equipped with electrically driven controls, as in the case of most standard convertibles.

The Studebaker Starlight coupe provides a distinctive appearance, the rear windows being reminiscent of Jaray streamlining. In the DeSoto Carry-All sedan the rear seat folds down to the floor, whereby the reverse sides of the back and cushion form a wooden floor with chrome strips that extend through to the front deck lid, giving 62 cu ft of luggage space. The Plymouth station wagon has a similar folding seat, which gives a continuous floor when the seat is not used. The spare tire fits into a circular floor well and is reached by removing a lid therein. Chevrolet does likewise, except that it is

Fig. 13—Buick Roadmaster Riviera



located behind the rear axle. The Dodge Wayfarer 3-passenger roadster has removable plastic side windows stored back of the front seat, which fill in the space between the soft top and the windshield when mounted on the doors, each with three metal dowel-retainers. The base of the top sides is "buttoned" to the body by small, open-ended, pivoted channel stampings, which, when reversed, hold the buttons in their closed ends by tension of the top material. The Jeepster, introduced last year, has a low-hung Continental-appearing body with the rear passenger compartment accessible via a fender step: the front end remains the conventional Jeep but in highly ornamental form.

Lincoln has abandoned the unit body and frame construction, leaving the field to Nash and Hudson. It has been noted that gasoline tanks are being secured to the luggage compartment floor. Chevrolet is now anchoring the top of the shock absorbers to the body floor just back of the rear seat. It will be interesting to note the increasing "underneath attachments" in the future since, if this process continues step by step, the unit body and frame shall have been achieved.

Body Shell and Windshield

The GM "A" body incorporates a single roof bow of large cross-section extending across the body between the center pillars, replacing three former smaller bows. The roof, as measured from the ground on the complete car, has been lowered 2½ in. and has been moved farther to the rear. The windshield is assembled from the outside and held in position by a rubber channel fitting around the windshield opening, the steel lip of which extends into a slot in the channel. The windshield glass is installed in a similar but wider slot from the outside of the body. In this way the glass is held to the body in a cushion of rubber outside the actual body shell. Should any great impact force be imposed on the glass from the inside, it will be unseated from the channel and fall away from the body. The Nash Airflyte roof has been lowered 6 in. In the GM "C" bodies, box-section roof rails extend from cowl to wheelhouse, the rocker panels from front-door pillar to wheelhouse, the center pillar and the cross-member under and at the back of the rear seat. At the rear of the body the cross-member is a strong channel section. Six channel bars support the ribbed, solid-steel floor. All GM bodies have the rear compartment footrest embossed in the floor panel, allowing ample leg room, which is not reduced when the front seat is moved back. The rear seat support also reinforces the floor. In the Chrysler-built cars a separate, fixed footrest is incorporated in the rear compartment of all 4-door sedans. There has been a slight narrowing of cars. The entire Chrysler-built line has been so affected, the Dodge, for instance, dropping from 75¾ in. to 72⅞. The Chevrolet front bumper and sheet metal have been narrowed from 72⅛ in. to 70½, while the rear dropped from 74¾ in. to 73⅝.

A larger dash-to-frame brace is used on the Chevrolet extending downward from the top of the dash panel at the side of the engine recess to the juncture of the dash and toe panels, at which point it widens out to the front corner of the body and then tapers forward to a narrower width at the bottom. It unites the body and frame over a greater length and increases front end stability. A similar functioning brace is used on all GM bodies.

Better forward and side visibility through increased windshield area and lowered hoods is a distinct contribution to safety, together with lowered and wider rear windows and lowered rear-deck lines for rear vision. Chevrolet's windshield area is now 863 sq in., an increase of 30% over the previous model; both front door windows have an area of 641 sq in., a 17% increase; rear door windows 603 sq in., a 16% increase, and the back window 640 sq in. or 70%. Nash has 700 sq in. of windshield area over 660 for 1948 and 37% more area is swept by the windshield blades. Chevrolet has increased the length of the wiper blades 2 in., with a cleaned area for both wipers of 504 sq in. as against 364, a 39% increase. The Plymouth has an area of 843 sq in., an increase of 37%, and the rear windows 403.8 sq in., an increase of 35.4%. Buick has increased its total area 22.8%. The Cadillac windshield provides more than 6½ sq ft of vision, the rear window just under 6; total glass area is more than 24 sq ft.

The curved windshield is not new, having been used in one piece in the 1934 Chrysler Airflow Imperial. The windshields of all GM cars are curved and of 2-piece construction. The sides curve back on a smaller radius. All Ford-built cars have straight V windshields except the Lincoln Cosmopolitan, which is curved and of one piece, as is the case with the Nash. The Hudson curved windshield is of 2-piece construction. All Chrysler-built cars, Kaiser-Frazer, Packard, and the Studebaker Champion have V windshields. The Studebaker Commander began in 1947 to use a one-piece straight V windshield with a small-radius center. Trico's Rainbow articulated windshield wiper arm permits the rubber to flex and conform to the contour of the glass and maintain perfect wiping contact throughout its arc of travel as the contour shape changes.

The popularity of windshield visors among car owners is a challenge to the body engineer. The old cadet visor is a far cry from the present version but its field use is an indication of a real need. It is interesting to note that it is optional equipment on all GM "A" bodies. Part of their 5½-in. increased width is due to the important narrowing of the windshield pillar from 4¼ in. to 2½, as measured in the line of vision. The dream of bringing this dimension close to man's interpupilary distance is at last close at hand. In addition the pillar, as in the case of all curved windshields, is moved back toward the driver and the curve in the new windshield glass covers the area formerly occupied by it. Rear windows are 8 in. wider than formerly and 3 in. higher. The side window vertical glass opening has been increased 1 in.

Nash bodies have only two soldered areas, just below the end of the drip molding at each side of the rear quarter panel over a seam length approximately 2 in. long. The "600" 4-door sedan body shell has a total of 7824 spot welds, the Ambassador, 8001. The roof panel is exceedingly long, taking in the entire cowl upper panel, windshield opening, and the rear section, including the entire rear window opening.

The use of under coating is extremely popular in

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the field, since it achieves silence and gives a sense of solidity. Several bus body manufacturers are employing it, and its use will no doubt creep into volume production. Nash has been using sand Mortex over the years to silence panels and it is now brushed on the inner surface of the floor pan and trunk floor with the idea of obviating later undercoating.

Doors and Windows

The width of the center pillars of the GM "A" bodies above the belt, including the door and body pillar, is reduced 1¼ in. to improve visibility at the center of the car. The door openings have been increased 6 in. in front and 9 in. in the rear. Sport and business coupe doors are 2 in. wider. The door hinge centers are more nearly vertical than previously, so that the doors do not rise as much when opened and therefore require less effort. The doors of the Buick series "50" and "70" are provided with a new spring-actuated construction to provide easier opening and a more positive hold-open feature. Integral door check links and hold-opens of spring and toggle arrangement are used. The check link end is attached to the front body hinge pillar for the front door and to the centar pillar for the rear door by a threaded clevice. The front door has two spiral torsion clock springs assembled to the toggle linkage formed by the check link and also a retainer, which is attached to the door inner panel by two screws. With the aid of these two springs only a slight pressure is needed to open the doors. The spring and toggle arrangement holds the door in the full open position and makes the door opening operation easier. The rear doors are the same except that two helical torsion springs are used. The outside handle on the Buick is rotated through a 22-deg angle instead of the previous 90-deg to release the lock. The locking action of the bolt is up and down at the striker, which is of a new adjustable type that eliminates the door bumper wedge plate, bumper casing, and bumpers. The lock is named the U type, due to the shape of the lock assembly.

The door handles on the GM "A" bodies are mounted at the rear of each door, just below the belt holding, being chrome-plated die castings with cylindrical pushbuttons in the hubs. Since the key locks are located in the front door pushbuttons, the separate locks in the door panels are eliminated. In the new lock, the bolt is a roller-tipped arm, which, when the door is closed, engages a cam-shaped slot in the lock pillar. The cam causes the bolt to rise as it enters, holding the door tightly and securely when it reaches the top of the slot. The internal mechanism of the lock holds the bolt in this position until it is released by pressure on the push-button or by means of the inside handle. There is the usual safety-catch feature to prevent the door from flying open if only partially latched. The door check and hold-open mechanism is combined into a single unit consisting of a curved spring steel strap attached to the hinge pillar and extending into the door through an opening in the forward edge thereof. A steel roller is installed on the inside vertical edge of the door opening and a wedge-shaped steel block is attached to the side of the steel strap so that it bears against the roller. The hold-open action is provided when the door is open and the roller is forced to pass over the wedge on the strap, whose tension is then sufficient to keep the wedge in front of the roller, holding the door open until it is intentionally closed. The door stop consists of a hook formed in the free end of the steel check strap, engaging the rear surface of the roller when the door is fully open, preventing further movement. For safety, the inside door handles on all cars are raised for opening. Nash has discarded the covers over the locks, as they consider the extra cost not justified by the theoretical improvement in antifreeze protection in winter, and since either door can be entered, regardless of how the car was locked. If the driver should be locked out because of lock freezing or loss of the door-ignition key, it is possible to enter via the trunk, which has a different key. The rear seat can be loosened by taking out two bolts at the top.

In the GM "A" bodies the ventilating panes are equipped with friction-type mountings. The GM "B" body retains the crank-type regulators. The Chrysler-built cars have adopted the vertical guide in the front door for the window and ventilating pane. This also applies to the rear door of 4-door sedans. Each door window can be quickly opened or closed with less than two full turns of the regulator handle. Additional theftproof protection is afforded by a screw-type latch on each ventilator pane, which, when tightened, prevents it from being opened. It can be released when the screw is turned to its extreme outer position. The GM Inland Mfg. Division has introduced a self-sealing weather strip to support the glass in the body panel or windshield opening. A concavely rounded diamond section rubber-filler strip is inserted in a central outside groove of the rubber strip, expanding it and thus sealing, without cement, the body panel and glass in their respective grooves. The Oldsmobile "98" and Buick backlights are of tempered glass.

Trunk

Increased storage space, counterbalanced and leak-proof trunk lids mark the new trunks. In the GM "A" bodies helical compression springs counterbalance the weight of the lid, the entire mechanism being enclosed within a luggage protecting cover. The storage space has been increased 20%. The spare tire is carried in a vertical position in a well at the right side. At its right there is sufficient space for the storage of small articles, including the bumper jack and handle, which are insulated from the steel floor by a rubber floor mat. A long, helical holddown spring retains the jack. The trunk lid weather strip is applied to the edge of the lid at the sides and on the bottom. The seal across the upper edge of the lid opening is laid directly into the gutter. It is no longer necessary to rotate the lid handle. A simple turn of the key accomplishes the dual functioning of unlocking and unlatching and it is only necessary to slam the lid shut. The Buick trunk lid is based on the same principle except that helical springs are used instead of compression springs. The wider trunk lids permit removing the tire with the disturbance of a minimum amount of baggage. In the Chrysler-built cars the bumper jack is kept from rattling by exerting tension on the

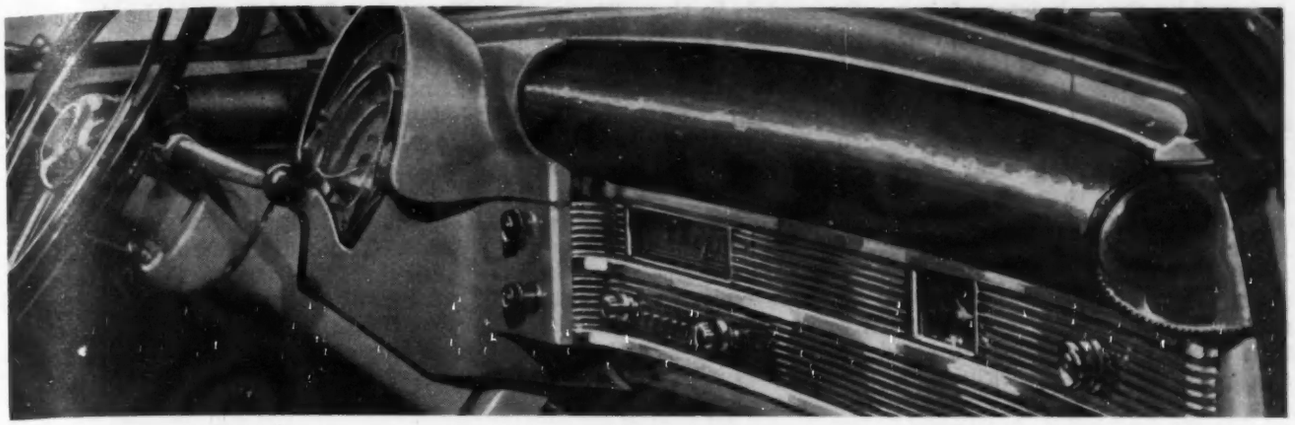

Fig. 14—Chrysler sponge rubber, leather-covered crash pad at top of instrument panel

holding helical spring by adjusting the jack lift to which it is attached. Except for the trunk lid, all surfaces inside the Cadillac trunks are carpeted for increased insulation and as a precaution against scuffing luggage.

Instrument Board

Instrument panels are of varied design, ranging from unified groupings of all instruments, as in the Oldsmobile, Pontiac, Cadillac, and Chrysler, or the circular grouping of Chevrolet and Ford, to separate speedometers, as in the case of Buick, Studebaker, and the other Chrysler-built cars. In the Pontiac instruments the lower half of the surface of the four individual gages is covered with a chrome-metal half-circle disc with the gage name pierced therein. The speedometer is provided with a molded plastic lens to magnify the mileage figures. Most of the instruments utilize black or ultraviolet lighting, operating on the same principle as that of the fluorescent instrument lighting on Air Force planes in which the invisible near ultraviolet radiation activates phosphorescent coatings on the dials, numerals, and pointers. The background is entirely black and only the markings glow. Other methods include edge lighting and translucent lighting having various levels of brightness at the control of the driver. In the Chrysler-built cars the headlight and panel light switches are of the rotary type. The Chrysler instrument board has a decided curvature in plan view, a slightly larger radius thereof being practically tangent to the V windshield panes. The instrument group is ahead of the steering wheel and a convex crash pad extends from the instrument group to the right side, affording protection to the passenger. (See Fig. 14.) The instrument board is then recessed forward under the pad with the radio, clock, and glove compartment therein. Rotary-type switches are now used on all Chrysler-built cars. Clear, plastic control knobs, set off with jet-black inserts and white lettering, complement the chrome of the instrument panel fittings in Studebaker cars. In the Nash Uniscope the instruments are concentrated in a group, mounted above the steering column and close to the normal line of vision. The dials have been made proportionately smaller. The lower lighting intensity on the dials has been found to be important in view of their reduced distance from the driver's eye. An intensity-control switch is provided, concentric with the main light switch on the left-hand side of the steering column. All GM cars have an access hole at the left-hand side of the dash in order to reach the back of instruments, wires and switches behind the instrument panel. The hole is closed by a sheet-metal door covered with noise and heat insulation. A sponge rubber seal is used around the edge.

Seats and Upholstery

Practically all seats have been increased in width, front and rear, due to the wider bodies and to moving the rear seats forward. Free-running rollers are used in the front seat adjustment in the GM "A" bodies, with a range of 4½ in. The "C" bodies have a ball and roller adjustment. Dodge has a 5-in. horizontal and 1-in. vertical adjustment. The Nash adjustment has been increased to the same dimension and the rise, while moving forward, has been increased from 7/16 in. to 1¼. Pontiac has a safety roll along the top of the front seat back, similar to the 1940 Dodge. Fully enclosed, mattress-type coil springs are used in the Oldsmobile "98" seats; the seat backs are made of upholstery-type helical coil springs. Heavy insulating pads and jute protect the resilient cushioning material from wear. Foam rubber seat cushions are regular equipment on the "98" and the DeLuxe series "76" and "88". The Chevrolet front seat back is 1⅝ in. thinner, due to the use of flat, zig-zag wire springs. They are also used in the cushion, which is made up of 21 of them, crimped to the front and rear bars of the all-steel cushion frame. The seat back is built up of 13 double rows of zig-zag elements, slightly smaller in diameter than those used in the cushion. The latter are covered by an insulator unit (to distribute the load over them) which, consists of three sections, each of which is made up of wires laid across the width of the cushion and stitched to a burlap backing. A layer of gray cotton padding covers the insulator and an additional layer of cotton padding is placed around the outer edge. On the DeLuxe models, the foam rubber pad is then attached and

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covered by the upholstery fabric. On models in the Special series, a layer of rubberized hair and a layer of cotton padding replaces the foam rubber. The seat back is similarly trimmed with an insulator over the springs covered by a unitized pad over which the upholstery fabric is placed. The unitized body consists of one layer each of gray and white cotton enclosed in a cloth sack.

In the Chrysler-built cars the seat cushions can be made firmer, if desired, by installing extra springs. These springs, available in sets of six, together with the required number of hog rings, are made in two types, firm and extra firm, and selection depends upon the firmness desired by the person most frequently riding in the car. In the Studebaker Champion Regal Deluxe the front seat base is bound with a 4-beaded chrome ring. Alligator leatherette trim, plus nylon upholstery, are used in the Land Cruiser. The Chrysler Windsor New Yorker sedans use all-nylon fabric with nylon-faced materials available for interior trim on Chrysler and Plymouth convertibles.

The Chevrolet regular upholstery combination for the DeLuxe sedans and Sport coupe is based on flat-woven fabrics. The seats are covered with tan, striped-pattern broadcloth accented with green pin stripes. The doors and side walls are trimmed with solid color fabrics, the upper area being brown cloth, the central area tan cloth, and the leather fabric scuff pad brown. The head lining and carpet have

Table 4—Optional Color and Upholstery Combinations—Cadillac

Color Combination No.	Body Color	Upholstery				Wheels	
		Series "61"	Series "62"	Series "60"	Convertible Coupés	Standard	Optional
1	Black	All	All	All	All	Black	/1
2	Triumph blue	37	40, 41	44, 45	64 61, 66, 65,	Triumph blue	/1
3	Dartmouth green	38	42, 43	48, 49 46, 47	62 61, 66, 65	Dartmouth green	/1
4	Tyrolian gray	37	40, 41	44, 45	65 61, 66	Vincennes red	/2
5	Cypress green	38	42, 43	48, 49 46, 47	61 62, 66, 65	Cypress green	
6	El Paso beige	38	42, 43	46, 47	61 62, 65, 66	El Paso beige	/1
7	Horizon blue	37	40, 41	44, 45	64 61, 66, 65	Horizon blue	/1
9	Madeira maroon	38	42, 43	46, 47	61 65, 66	Madeira maroon	/1
10	French gray	37	40, 41	44, 45	65 66, 62, 61	Vincennes red	
12[a]	Ardsley green—upper Cypress green—lower	38	42, 43	48, 49 46, 47		Ardsley green	
13[a]	Kingswood gray—upper Tyrolian gray—lower	37	40, 41	44, 45		Vincennes red	/2
15[a]	Vista gray—upper French gray—lower	37	40, 41	44, 45		Vincennes red	
16[a]	Lucerne green	38	42, 43	48, 49 46, 47	62 61, 65, 66	Lucerne green	
18[a]	Avalon gray	37	40, 41	44, 45	65 , 66, 64, 61	Vincennes red	/2
19[a]	French gray—upper Lucerne green—lower	38	42, 43	48, 49 46, 47		Lucerne green	
20[a]	Horizon blue—upper Triumph blue—lower	37	40, 41	44, 45		Triumph blue	/1

[a] Two-tone combinations not available on coupés or series "75".

Optional Wheel Colors

/1 Vincennes red—/2 Lower body color

Example: 7/1 means horizon blue with Vincennes red wheels.
18/2 means Avalon gray with lower body color wheels.

Body Cloths

Series "61"	Series "62"	Series "60"	Series "75"	Convertibles	
37 gray dualtone cord	40 gray plain broadcloth	44 gray shadow broadcloth	81 tan vogue broadcloth	61 tan	65 red
38 tan dualtone cord	41 gray Bedford cord	45 gray Bedford cord	82 tan Bedford cord	62 green	66 black
	42 tan plain broadcloth	46 tan shadow broadcloth	83 tan plain broadcloth	64 blue	
	43 tan Bedford cord	47 tan Bedford cord	85 gray vogue broadcloth		
		48 green shadow broadcloth	86 gray Bedford cord	1 tan top	
		49 green Bedford cord	87 gray plain broadcloth	2 black top	
		To order leather and cloth combination: add "C" to trim code, that is, 44C.	Styles—7523L—7533L 89 tan Bedford cord only.		

Table 5—Interior Trim Used on Frazer Manhattan

Body Cloth	Sidewall	Headlining
Wedgwood blue dark face finish broadcloth	Wedgwood blue face finish broadcloth and Wedgwood blue dark face finish broadcloth	Wedgwood blue wool and cotton warp
Zero gray face finished broadcloth	Polar gray face finished broadcloth and zero gray face finished broadcloth	Polar gray wool and cotton warp
Dubonnet face finished broadcloth	Polar gray face finished broadcloth and Dubonnet face finished broadcloth	Polar gray wool and cotton warp
Teal blue face finished broadcloth	Doeskin face finished broadcloth and teal blue face finished broadcloth	Doeskin wool and cotton warp
Hickory brown face finished broadcloth	Doeskin face finished broadcloth and hickory brown face finished broadcloth	Doeskin wool and cotton warp
Dubonnet Bedford	Doeskin homespun and Dubonnet homespun	Doeskin wool and cotton warp
Saddle bronze Bedford	Doeskin homespun and saddle bronze homespun	Doeskin wool and cotton warp
Garden green Bedford	Glass green homespun and garden green homespun	Glass green wool and cotton warp
Teal blue Bedford	Doeskin homespun and teal blue homespun	Doeskin wool and cotton warp
Dubonnet Bedford	Pearl mist homespun and Dubonnet homespun	Pearl mist wool and cotton warp
Blade green face finished broadcloth	Green spray face finished broadcloth and blade green face finished broadcloth	Green spray wool and cotton warp
Aztec copper face finished broadcloth	Coral sand face finished broadcloth and Aztec copper face finished broadcloth	Coral sand wool and cotton warp
Teal blue leather	Teal blue vinyl	Teal blue vinyl
Cardinal red leather	Cardinal red vinyl	Cardinal red vinyl
Green spray leather	Green spray vinyl	Green spray vinyl
Wedgwood blue leather	Wedgwood blue vinyl	Wedgwood blue vinyl

harmonizing tones. A free-breathing pile fabric known as "Seaweave" in tan with a striped pattern is optional for those preferring pile fabrics. The solid-color tan and brown materials, applied to the side walls, are also pile fabrics with a chevron self-pattern. In the Special series, where only pile fabrics are available, the seats are covered with tan, striped pattern cloth reinforced with a synthetic rubber sizing on the back. The side wall materials are the same as in the DeLuxe models.

The Oldsmobile Futuramic DeLuxe models utilize 2-tone broadcloth and center panels of striped broadcloth. Foam rubber seat cushions are standard on the "98" and all DeLuxe "76" and "88" models. In the Cadillac "62" sedan rear compartment the seats and seat back inserts are upholstered in light tones of either gray or brown with broadcloth or Bedford cord optional. Seat back bolsters and arm rest trim are in darker tones of broadcloth. Door trim metal panels are cameo grain finish with harmonizing inserts. A broad heel pad extends up from the floor to improve the appearance and protect the upholstery. Floors are covered with pile carpeting. On the "61" sedan dual tone cord is used on seat backs and cushions with door panels in smooth-finish harmonizing fabrics. Stainless-steel trimmed beads highlight the door panel moldings, which are also in cameo grain finish. The various upholstery material and color combinations will be found in Table 4. The Kaiser-Frazer Corp. has delved considerably into materials and colors for interiors, which have been featured in the Frazer Manhattan. Table 5 lists this study.

Body Miscellaneous

The Nash tail, stop, and directional signal lights are mounted in the lower edge of the trunk lid. A trunk compartment light at the left side provides interior illumination at night, as it is connected to the tail light circuit. The trunk light serves a double purpose, as the ruby glass back of the bulb shines a red warning light to the rear when the trunk lid is opened, since in this position and during tire changes at night, the regular tail lights are ineffective. A mercury switch is being used on the Packard "160" and Cadillac "75" to turn on the trunk light automatically when the lid is raised. The Chrysler-built cars have adopted a bimetal blade circuit breaker to replace lighting system fuses. Chevrolet did likewise in 1948 and now all body wiring terminates at a junction block mounted on the lower flange of the instrument panel. It serves to separate the chassis and instrument panel wiring from the body wiring. Moving the defroster to the engine side of the dash has provided room in the Pontiac for a 12-terminal accessory wiring fuse block on the passenger side of the dash. Buick also uses a master fuse block, which takes care of the heater blower, directional signal and spot light,

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clock and dome light. The cartridge fuses are held by silver-plated beryllium-copper clips and in addition a plug-in type mounting for the directional signal flash is centrally located on the fuse block.

The GM Delco Radio Division has concentrated on further simplification of the tuning mechanism to permit easy station selection in the car while it is in motion. Most of their production is of a new type, which permits simple and quick setup of desired stations on the five pushbuttons as the car is moving from one territory to another and out of range of the desirable stations in a given locality. They also have available a speaker for use in the rear compartment, which improves the sound distribution in the car and eliminates the necessity of running the front compartment radio at an unduly high level to permit the rear seat passengers to hear a program satisfactorily with the usual road and wind noises encountered at high speed. Provision is made for switching on either or both speakers.

Due to the general trend toward making instrument panels narrower, from top to bottom, and a reduction in available space between the back of the instrument board and the face of the firewall, Philco has developed smaller sets. In one development it has been necessary to lengthen the radio considerably across the car to provide the necessary room for its components. Wartime experience has made it possible to reduce the size of the receiver and many of the components and at the same time to improve performance and life and to reduce service troubles. Among such improvements are miniature tubes, permeability tuned circuits, the combined miniaturization and greatly improved life and performance of resistors, condensors, transformers, tube sockets, and the like.

Arm rests are now placed on rear doors in view of the passenger's arm location. Chevrolet has a very neat combined, drawer-type ash tray and arm rest in the DeLuxe two-door models. A considerable number of cars are equipped with an electrically driven hydraulically actuated power system for window and seat adjustment control; also for operating the top on convertibles. The controls are two-way electric "touch buttons" individually located at each window as well as at a master control unit on the instrument board. Such equipment is standard on the Lincoln Cosmopolitan.

Nash is providing a bed formed entirely within the passenger compartment; the back cushion of the front seat swings down toward the rear to fill the space just forward of the rear seat. A kapok-filled accessory mattress of proper bottom contour is placed on the three horizontal cushions thus formed. The front seat back is of the divided type, when a bed is specified. Each side can be unlatched independently, permitting utilization only of the right side for a single bed while the driver continues on the road, or both can be let down.

Ventilation

The dual duct system is being used almost universally, taking air in through a screened opening at each end of the radiator grille, or through a special aperture in the fender below the headlight in the Oldsmobile, along the fender skirts and through the firewall into the passenger compartment. Each duct is controlled by a knob on the instrument panel so that the driver and front seat passenger may individually control the amount of ventilation on their side. The heater core is usually placed in the engine compartment away from the firewall or thereon, at the right side, with a temperature control valve, either manual or of the automatic preset thermostatic type and a sirocco blower. The Chrysler-Built cars and Buick place the blower at the extreme front. Since the level at which the air enters the ducts is lower than the outlet into the body, an automatic water shedder is established. Cadillac is an exception in placing the heater core on the front side of the firewall and receiving air from the left duct. The heated air is blown across the full width of the windshield and then through ducts extending into the front doors. This air defrosts the windshield and door glass and also circulates heated air into the upper area of the car. Underseat heaters and fans heat the lower area by discharging into both the front and rear compartments. Upper and lower area heating is thermostatically maintained by individually operated manual controls. All Chrysler-built cars retain the cowl ventilator, which prevents the pleasing lines of the hood continuing to the base of the windshield but which obviates the drawing in of air from above-the-road level. The duct system is vulnerable to the inhaling of the exhaust gases from the car ahead whether in dense, slow-moving traffic or when parked behind a vehicle whose engine is idling. Nash continues with its "weather eye" with greater heating effectiveness at low car speeds, better distribution of warm air within the car and a more effective water shedder.

Conclusion

It has naturally been necessary to touch on only a few high spots covering the many and various components of the present cars, and no complete study could be made on any one particular feature. It will, however, be seen that considerable progress has been made, the most gratifying being the many provisions that will ensure greater safety, such as the use of greater glass area and the elimination of blind spots. The step-by-step increase of compression ratios will be watched with considerable interest and especially the ability of the oil companies to produce the new fuels in quantity and at a reasonable price. The postwar cars are more comfortable to ride in, with less fatigue resulting from long journeys aided by superior suspensions and also by easier controls. Regarding the latter phase, new transmission developments relieve the driver of manual burdens in dense traffic and mental anguish, provided no hunting characteristics are present. Each individual has his or her own conception of beauty, hence the different schools of thought in body and sheet-metal design. New servicing problems call for new service techniques, which no doubt shall be forthcoming. It is too precarious to attempt to predict the nature of general conditions in the years just ahead but, as in every phase of activity, the law of economics will dictate just how our cars will have to be built.

Air Force Maps Human Tolerances

BASED ON PAPER* BY **W. R. Lovelace II, M.D.**

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AIR FORCE medical specialists are accumulating data on human tolerances and capabilities as guides for the design of aircraft and equipment for high speeds and high altitudes.

Four of the many physiological aspects of flying they have delved into—with the help of hundreds of government and private research agencies—are: the effects of acceleration, of decompression, of vibration, and of carbon dioxide concentration.

Researchers on acceleration effects have found that the amount of acceleration a human can stand depends on its direction of application to the body. In the pilot emergency ejection seat, subjects can sustain ejection at 15 g, yet exposure to far slighter accelerations in the foot-head direction for over 0.3 sec may rupture vessels about the head, and pilots find it impossible to rise from a bomber seat against a radial force of 3 g.

Air Force analysis of human ability to withstand decompression shows sudden loss of pressure in pressurized aircraft to be a minor hazard. More serious may be the discomforts induced in bystanders by jet exhaust and the toxic effects of CO_2 on air crews at both ground level and altitude.

1. Acceleration—Human tolerance to high accelerations of short duration applied from head to foot has been studied as a basis for design of emergency escape mechanisms. A vertical accelerator was built which could catapult subjects with various accelerations. Instrumentation recorded terminal velocity and acceleration. As testing progressed, accelerations were increased. Some 300 ejections with dummies and volunteer subjects were made without serious injury to test personnel.

Results of the investigation have already been applied in design of an automatic pilot ejection seat which catapults both pilot and seat from the cockpit with sufficient velocity to clear the vertical stabilizer of the airplane at airplane speeds up to 600 mph. Subjects are ejected with a velocity of 60-64 fps with a maximum acceleration of 15 g. That acceleration is 5-10 g less than that considered to be the safe skeletal allowance.

It has been found that the flexed spine may be injured by positive acceleration of a magnitude which the erect spine withstands readily. For that reason, it is important to maintain the spine erect during exposure to positive acceleration in either ejection or curvilinear flight.

Acceleration in the opposite direction is more dangerous. Shaw at the Aero Medical Laboratory at Wright-Patterson Air Force Base found that exposure to 1 g acceleration from foot to head for more than 0.3 sec leads to overdistension and rupture of vessels about the head, although exposure to higher accelerations for shorter periods does not cause such injury.

Indications are that relatively long exposure to negative acceleration above 3 g may decrease cerebral blood flow due to the arterial pressure drop, bringing on confusion and unconsciousness. Forceful cephalic displacement of the viscera could cause increase in thoracic pressure.

How greatly application of centrifugal force, such as a spinning airplane might apply, restricts man's locomotive ability has been demonstrated by experiments on five subjects in a human centrifuge.

1. Movement in the direction of the force was easy but hazardous. Falling 1 ft at 2 g knocked the wind out of subjects. It was concluded that falls of greater distances at slightly higher accelerations would often cause injury.

2. Movement at right angles to the direction of force is slow. The average time required to crawl across the end of the centrifuge, a distance of 7½ ft, increased by 2½ times at 1 g radial acceleration, 5 times at 2 g, and 10 times at 3 g. Three of the five subjects tested could not accomplish this task at 4 g. The time required to round a barrier which projected 22 in. from the back of the centrifuge increased by 2¼ times at 1 g radial acceleration, 6 times at 2 g, and 18 times at 3 g. All five subjects

* Paper "Physiological Aspects of High Speed and High Altitude Flying" was presentel at SAE National Aeronautic Meeting, Los Angeles, October 7, 1948. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

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stated that they could not accomplish the task at 4 g.

3. Movement against a radial acceleration of 2-3 g is almost impossible; subjects could not crawl, walk, climb a rope or a ladder, or rise from a bomber seat—indicating that a flyer's escape maneuvers directed against an accelerative force around 3 g may be ineffective.

4. Donning a parachute takes considerably more time under exposure to radial acceleration. Three subjects required an average of 17 sec to don parachutes under no radial acceleration. The average time increased to 21 sec at 1 g radial acceleration and 41 sec at 2 g. One of the three subjects could not complete the task at 3 g. The others required an average of 1 min, 15 sec. All agreed that they could not have donned the parachutes at accelerations more than slightly over 3 g.

2. Explosive Decompression—Air Force analysis shows that sudden decompression due to loss of a fuselage section up to 7000 sq in.—or a hole almost 8 ft in diameter—could be withstood safely by humans in an aircraft of 2000 cu ft flying with a cabin differential of 6.55 psi at 40,000 ft altitude. This area is about 10 times larger than any fuselage section likely to be lost, such as a bubble canopy, nose section, or escape hatch door.

The degree of decompression a human can withstand safely depends on the extent and rate of expansion of internal body gases in the lungs, stomach, and intestines. Maj. H. M. Sweeney of the Aero Medical Laboratory has shown that

$$RGE = (P_c - 0.91)/(P_a - 0.91) \quad (1)$$

where

RGE = Relative gas expansion
P_c = Cabin pressure before decompression, psi
P_a = Ambient or final pressure after decompression, psi
0.91 = Vapor pressure of water at body temperature, psi

For rapid or instantaneous decompressions (approximately 0.01 sec or less), the maximum tolerable RGE is 2.3, experiment indicated. As the time of decompression increases, there is more time for the dissipation of the pressure differential through neighboring tissues and the gases can escape from the body. Thus, maximum tolerable RGE increases with time:

$$RGE_{max} = 2.1 + 17.0\,t \quad (2)$$

where

t = time, sec

An expression for the time of decompression can be derived from Fliegner's equations for the flow of air from an orifice:

$$t = 0.22\ (V_c/A)\ \sqrt{(P_c - P_a)/P_a} \quad (3)$$

where

V_c = Volume of pressurized cabin, cu ft
A = Cross-sectional area of hole caused by structural failure, sq in.

(This equation, which assumes the orifice coefficient to be unity, tends to be conservative. It underestimates the time for decompression if the orifice coefficient is less than unity, as it may be.)

A combination of these last two equations yields an expression for RGE_{max} in terms of cabin volume, cabin and ambient pressures, and cross-sectional area of the lost fuselage section:

$$RGE_{max} = 2.1 + 3.7\ (V_c/A)\ \sqrt{P_c - P_a)/P_a} \quad (4)$$

The criterion of safety for an air crew during any decompression in a pressurized-cabin aircraft is that RGE_{max} as calculated by Eq. (4) be greater or equal to RGE as calculated by Eq. (1), both taken at the maximum service ceiling of the aircraft. A decompression safe at that altitude will be safe at any lower altitude.

Decompression experiments on human subjects demonstrated that pressure in the middle ear is relieved automatically for rapid changes in outside pressures. A normal ear adjusts to a rate of pressure loss of 100 psi per sec without any aural or pressure sensation at all to the subject in top-notch condition. A crew member with a cold or other respiratory infection might feel some sensation, and a passenger with an occluded sinus would suffer severely from pain when either the volume or the pressure of the trapped gases increased as little as 30%, regardless of the rate of decompression.

The Air Force limitation of drop in cabin pressure to 1 psi per sec is evidentally quite conservative.

3. Vibration—Military pilots have expressed uniform appreciation of the lack of noise and vibration during flight of jet aircraft. Jet aircraft, they say, are less fatiguing and more pleasant to fly than conventional aircraft.

But exhaust from jet airplanes on the ground can affect people in their vicinity. RAF experimenters found that when subjects stand close to the outflow of a jet engine on a line 45 deg from the direction of the jet, noise intensity and pitch are subjectively greater when they face the jet than when they turn the side of the head to it. If their mouths are open, exposing the teeth to the jet, subjects report they feel as though the teeth are being drilled. They complained of deafness, ringing in the ears, dizziness, indefinite discomfort from noise and weakness, feeling of unsteadiness, lack of concentration, vibration, and ill-defined paresthesia.

Parrack, at Wright-Patterson, found that if a person stands close to the exhaust of a jet when the range of vibrations is from 4000 to 10,000 cps and holds his hands up with fingers outspread, the skin between the fingers becomes too hot to bear in about 10 sec. At 700 to 13,000 cps, the jaw and skull seem to vibrate; larger muscles vibrate at lower frequencies.

4. Carbon dioxide—Most modern large aircraft carry carbon dioxide for fire-fighting purposes. If the gas escapes, it can be quite toxic to humans. Direct evidence of the toxic effects is meager in the literature, but a review of the problem made last year tentatively fixed the maximal safe carbon dioxide concentration at sea level at 5% by volume for 5 min or less, 4% for 5 to 15 min, and 1% for 15 min to 2 hr. Tolerance of carbon dioxide is a function of its partial pressure, so that higher concentrations can be tolerated at altitude. Altitude equivalents can be calculated from sea level data; 4% by volume at sea level equals 5% at 5000 ft, 6% at 10,000 ft, and 7.5% at 15,000 ft.

A Versatile Car Testing DYNAMOMETER

BASED ON PAPER* BY

Neil MacCoull

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Beacon Laboratories

EIGHTEEN years ago, in 1931, the chassis dynamometer described in this paper was installed. It has been in practically constant use since then and has proved to be a valuable instrument for car testing. Because this design is unique in its mechanical simplicity, and has proved to be sufficiently rugged to have carried out over 1,000,000 miles of car testing with almost no service difficulties, a description of its details is given here for the information of those interested generally in chassis dynamometer installations. Most oil companies have installed chassis dynamometers for examining the fuel and lubrication requirements of various automobiles and their performance with various fuels and lubricants, but many of these units are relatively elaborate and costly.

One of the first installations of apparatus on which an automobile could be run under load in a building in this country was made about 1907 by the Automobile Club of America in New York City. Later, this equipment was transferred to Yale University, and was described by Lockwood in 1915.[1] A second report of data obtained was published in 1922.[2] Full credit is hereby given to the installation as set up at Yale, as the inspiration for this design, and to data supplied by Lockwood as a basis for the quantitative design to accommodate average cars of that period.

The principal novel feature of the installation described here is the incorporation of a large fan, driven indirectly by the car through the traction wheels, and serving the dual purpose of simulating the air resistance and cooling of cars on the road.

Fig. 1 indicates the schematic arrangement. It will be seen that the rear wheels of the test car rest on large traction wheels carried by a truck axle. The propeller shaft of this axle drives through a gearbox and an electric generator to a second axle, which is belted to the fan. The pulley ratios used in this drive system are such that the air discharge velocity from the fan equals the car speed approximately. The fan size has been selected so that the power required to drive it may be made equal to the power required to overcome the car air resistance by adjustment of the outlet area of the fan nozzle.

Additional power absorption, equivalent to car friction, or hill climbing, is accomplished by the electric generator. Measurement of the power absorption by both fan and generator is made by the torque reaction of the housing of the axle, which supports the traction wheels, in the same manner as is customary with conventional cradle dynamometers. To this end, the axle housing is "cradled" on ball bearings, in which it is prevented from rotating by a torque arm and linkage to a scale system. This scale system is calibrated to read in pounds of draw-

[1] See SAE Transactions, Vol. 10, Part I, 1915, pp. 68-91: "Practical Testing of Motor Vehicles," by A. B. Browne and E. H. Lockwood.

[2] See SAE Transactions, Vol. 17, Part II, 1922, pp. 384-428: "Chassis Friction Losses," by E. H. Lockwood.

* Paper "A Versatile Car Testing Dynamometer" was presented at SAE National Passenger Car, Body, and Production Meeting, Detroit, March 10, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

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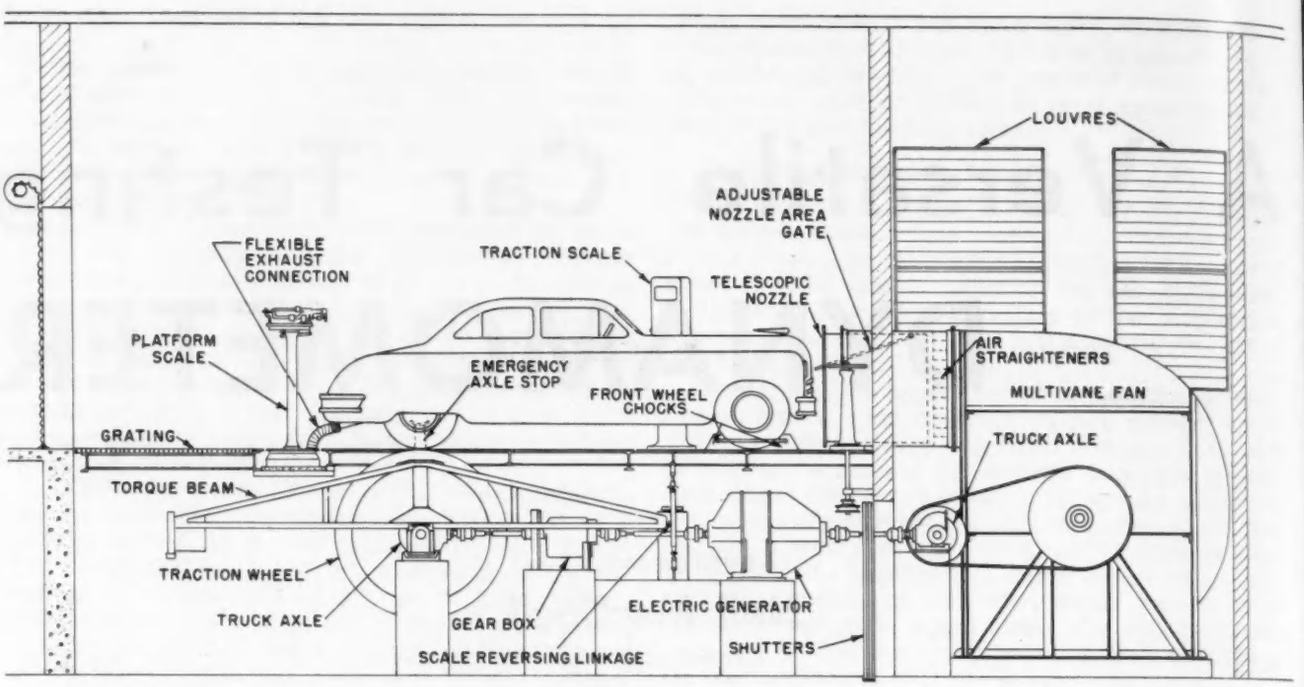

Fig. 1—Schematic diagram of chassis dynamometer

bar pull or traction at the circumference of the traction wheels, as is customary in railroad terminology. Its convenience in measurements of automobile performance was emphasized by Lockwood many years ago.[1]

General Considerations

The power delivered by the rear tires of a car to drive it at a given speed on a level road may be broken down into two main components:

1. Front-wheel rolling resistance.
2. Air resistance.

If these two factors can be reproduced by the loading system of a chassis dynamometer, cars tested on it will reveal the same performance as on a level road. Examination of the two components listed above indicated that this may be accomplished by simple means.

Rolling Resistance of Automobiles

A study of rolling resistance shows that it is dominated by tire resistance,[3] and that the friction of ball or roller bearings normally makes up such a small part of the total that serious errors will not result even if they are neglected. For instance, typical cord tires have a rolling resistance that increases slowly from about 1% of the load carried at zero speed to about 1.6% at 60 mph.

However, the wheel bearings have a traction resistance of hardly 0.1% of the load. Where ball bearings are used, the resistance may be still less. Rear wheel resistance too is similarly dominated by tire resistance and though more bearings are involved in the power transmission system, only a few carry enough load to account for much friction unless lubricated with a heavy oil or grease, which develops abnormal resistance at low temperatures. As an example of how small bearing resistance may be, it is of interest to note that a total resistance of freight train wheels and their plain bearings may be as low as 0.15% of the load carried, at low speeds.[4]

Experience shows that the rolling resistances of front and rear wheels of automobiles, when extrapolated to zero speed, normally average about 1.1 and 1.3% respectively, of the load carried. At 60 mph these values rise to about 2.0 and 2.4%, respectively. For average cars these front-wheel values are equivalent to traction values of about 20-25 lb at zero speed and 35-42 lb at 60 mph as shown by the curve marked "Front Wheels 1946-1947" in Fig. 2. These values may be higher in case of maladjustments, such as cramped bearings, wedged grease seals, dragging brakes, excessive front-wheel toe-in. Normally, such conditions would be corrected before any car tests are run.

It is possible to simulate car rolling resistance on the chassis dynamometer, by an electric load on the generator, which increases slowly with speed by means of a constant voltage regulator. Such a load may be set at a very low speed, such as 1 or 2 mph, where air resistance is practically zero.

Air Resistance

The air resistance of a car varies approximately as the square of the car speed—so does the load on a centrifugal fan. By suitable selection of the capacity of such a fan, it may be mechanically

[3] See SAE Transactions, Vol. 50, February, 1942, pp. 37-39: "Rolling Resistance of Pneumatic Tires as Factor in Car Economy," by W. F. Billingsley, R. D. Evans, W. H. Hulswit, and E. A. Roberts.

[4] See Fig. 9 of University of Illinois Bulletin No. 167, 1927, "Freight Train Curve Resistance on One-Degree Curve and on Three-Degree Curve," by E. C. Schmidt.

coupled to the drive wheels of a chassis dynamometer so as to absorb the same power as required to overcome the wind resistance of a car on the road, at all car speeds. Furthermore, the air discharge from this fan has sufficient volume to provide an excellent means of cooling the car radiator and underparts. By suitable choice of fan size, nozzle area, and drive ratio between the drive wheels and fan, it is possible to obtain the same air velocity as the car speed, while absorbing the same power that would be required to overcome wind resistance on the road. Such a relationship would hold for all car speeds, since centrifugal fan characteristics are such that the discharge velocity varies directly with speed and its torque as the square of the speed. Assuming that the fan is correctly selected for this use, adjustment of the outlet nozzle area will result in varying the power absorbed at a given car speed. This adjustment provides about $\pm 25\%$ range in load without appreciable change in air velocity.

In order to duplicate the air resistance of a car on the chassis dynamometer, this factor must be obtained from this road. This may be done directly by applying loads equivalent to previous measurements of the air and front-wheel resistances of each car, or indirectly by loading the dynamometer until the same engine manifold vacuum is observed, as was previously observed on the road. In either case a road test is required for *each* car, and the errors characteristic of road tests due to head winds, grade, surface, temperature, and so forth will creep in unless suitable precautions are taken to circumvent them. It is thus apparent that considerable study is warranted on methods of measuring the air resistance of cars.

There are three methods in general use for determining the air resistance of automobiles: wind tunnels, coasting down a hill, and deceleration on a level grade. The coasting method, which appears to be the simplest where suitable gradients are available, consists of determining the steady speed at which a car coasts down a known gradient in neutral gear or with open clutch. To obtain this steady speed a long hill of uniform grade is desirable, and several runs are required, each starting at the maximum speed obtained on the previous run, until no acceleration develops. Such runs should be made when the wind is almost nil. The force causing car movement is the total weight of car, crew, equipment, and so forth, multiplied by the sine of the gradient angle, which, for the hills normally used, is closely equal to the gradient in per cent. This force equals the air resistance plus the rolling resistance of all wheels. When these rolling resistances are measured on the chassis dynamometer, they may be subtracted from the total car resistance, leaving the net wind resistance. Where hills of different gradients are available, data may be obtained to solve simultaneous equations incorporating the two variables of air and rolling resistance without recourse to friction data from the dynamometer.

For many years style has limited differences between cars made during any year, so that there is but little aerodynamic difference between the high-production makes, which account for over 90% of all cars on the road, and the average for all of them. This permits simplification for certain types of car testing on chassis dynamometers because it is permissible to adjust the load-speed characteristic to the average resistance of any year's high-production cars, without making individual adjustments for each car. This reduces the probability of introducing error from the road on any one test and saves the time required to determine the air resistance of other cars either directly, or indirectly by means of manifold pressures. Of course the air resistance of cars deviating from the average in size or other characteristics, will still have to be predetermined on the road.

In a very interesting study, Lay,[5] of the University of Michigan, has discussed the deceleration and coasting methods of determining air resistance, and indicated his preference for the latter. He also described an additional method in which the whole car body was "floated" on the chassis so that its air resistance could be measured directly by a spring scale attached to the frame. For obvious practical reasons this method was not applicable to automobiles as marketed, but required a special body construction and mounting. For simplicity and academic reasons, the body construction was a straight-sided box entirely enclosing a conventional chassis, but with all corners and edges broken to a 9-in. radius. In spite of the large frontal area of 33.2 sq ft, the air resistance at 60 mph was only 123 lb, giving an aerodynamic coefficient of 0.00104 for an exponent of 2.0 Thus, this almost unstreamlined body, with about 20% greater frontal area than conventional cars of that period, had an air resistance only about 75% as great! This unexpected result was checked by the deceleration method at the General Motors Proving Ground, where a coefficient of 0.00103 was obtained.

Table 1 summarizes published data on average automobile air resistance as it has changed over the past 30 years. The data were taken by various methods. It should be pointed out that reliable data from the road require very careful procedure. Precautions must be taken to minimize the effects of varying rolling resistance caused by changes in tire inflation pressure, axle lubricant temperature, and so forth; runs should be made in opposite directions to average the effects of unavoidable gradients and particular attention should be made to avoid the errors produced by any headwind. It will not cancel out by the simple expedient of averaging runs in opposite directions, since air resistance varies as the square of speed. Averaging such runs will indicate resistance greater than it should be, by the square of the wind velocity. Neglect of even a 10-mph wind will accordingly indicate an air resistance 25% high at a car speed of 20 mph, 4% at 50, and so forth.

The average values of air and rolling resistance for 1939, as well as 1946-1947 cars, are indicated in Fig. 2, together with the desired chassis dynamometer traction curve, which reproduces these average car

[5] See SAE Transactions, Vol. 28, 1933, pp. 177-186: "Is 50 Mpg Possible with Correct Streamlining?" by W. E. Lay; also SAE Journal, Vol. 27, July, 1930, pp. 5-14: "Wind Resistance of Automobiles," by F. W. Pawlowski.

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Table 1—Air Resistance of Automobiles at Various Periods

Source	Cars Tested: Number	Cars Tested: Models	Average Frontal Area, sq ft	Aerodynamic Coefficient	Average Air Resistance at 60 Mph, lb	Test Method
University of Kansas Bulletin No. 18	18	1917-1925	27.8	0.00235	235[a]	Tunnel
University of Kansas Bulletin No. 33	55	1925-1922	27.1	0.00178	175[b]	Tunnel
Yale	13	1926-1928	27.3	0.00173	163	Coasting
W. E. Lay	1	"Box-car"	33.2	0.00104	123	Direct
Texas Co.	5	1939	23.9	0.00166 0.00142	143 122	Coasting Decelerating
Texas Co.	7	1946-1947	21.9	0.00159	124	Decelerating

[a] Extrapolated from 40 mph.
[b] Extrapolated from 50 mph.

loads and is, of course, the sum of these two component resistances.

This chassis dynamometer therefore makes possible adjustment to the requirements of any car merely by adjusting for front-wheel rolling resistance at about 1 mph (where the air resistance is negligible) by means of a constant voltage regulator on the generator, and by adjusting the blower outlet area to absorb the desired traction at 60 mph. All intermediate speeds will then closely approximate level-road loads.

Principles of Blower Selection

Calculations of blower performance may be made at any convenient speed, which in this case is taken as 60 mph. The corresponding velocity pressure[6] is 1.74 in., which should be developed by the fan at this car speed. A type of blower is selected with a characteristic such that the total pressure reaches a peak near the air volume giving maximum efficiency, and the design operating point should be at or near this peak.

For the problem at hand it is convenient to modify the scales of conventional fan performance curves, in which total pressure and horse-power are plotted against air volume, at a constant rpm. The total pressure scale may be converted to air speed from the equation for velocity pressure.[6] The air volume scale may be converted into a scale of fan outlet nozzle area by the use of the air speed at each air volume. Finally, the power scale may be read directly in terms of traction[7]. By this means, Fig. 3 was prepared for a Sturtevant: single width, double inlet, size 14 multivane fan at 234 rpm. The heavy parts of the curves represent the range of traction values, obtainable by varying the fan nozzle area, over which the air velocity varies only about ±1 mph from the desired 60 mph. The desirability of locating the total pressure peak near the main operating point becomes evident. The range of satisfactory operation for this fan is thus at least from 115- to 182-lb. traction. When a 3 mph drop in air speed (5%) can be tolerated, it becomes extended to about 100 lb on the low side, and 200 lb on the high side.

The traction curve approximates a straight line, which it would be if the fan efficiency and air speed were constant along its length. A dotted straight line on Fig. 2 shows the relation between traction and nozzle area of a 60-mph air steam at 100% fan efficiency.[8] A similar straight line is drawn for a 70% fan efficiency. These traction lines hold for any size fan, and since there is little difference in fan efficiency over a reasonable range of sizes of similar designs, the traction curve shown is a reasonable approximation for other sizes of fans. The principal effect of fan size is to move the air speed and efficiency peaks laterally, larger fans developing the peaks at larger nozzle areas. The effect of fan size on the traction curve will be to shift the location of the bump, which is the combined effect of the efficiency and air-speed curves.

The positions of the air-speed peaks for several fans, similar to the No. 14 fan but differing in size, are indicated in Fig. 3 by the locations of size numbers 12 to 16. It is readily seen that if the mean traction desired for air resistance is about 100 lb, a No. 12 fan should be used, while if it were 200 lb, the No. 16 should be used.

Before making a final selection of the required fan, consideration should be given to fan noise. The No. 14 fan used in this installation has a blade tip speed of about 4800 fpm at 234 rpm, or 60 mph air speed. The noise level is quite satisfactory, being less than that of any car tested so far. A smaller unit requiring higher blade speeds might develop a noise level high enough to interfere with some car tests.

The fan outlet is provided with a set of "egg-crate" straighteners and with a telescopic section that permits testing of most cars with a given distance between the nozzle and the car radiator. This is considered desirable in making special radiator cooling tests. The outlet is 55 in. wide, and adjustment of it is obtained by a hinged gate, which varies the height of the air column from the floor, as indicated in Fig. 1.

Car Weight and Acceleration

It is a remarkable fact that more than 57% of the cars on the road weigh within 150 lb of an average weight of 3250-lb,[9] and more than 95% deviate less than 500 lb from this average, or about

[6] Velocity pressure in in. of water = $(Mph)^2/45.5$; or $Mph = 45.5\sqrt{P}$.

[7] Traction in lb = 375 × hp/mph.

[8] Traction in lb = [(Nozzle area in sq ft) × $(mph)^2$]/400.

[9] See Automotive Industries, Vol. 98, March 15, 1948, p. 129, data on weights; Automotive News Almanac, June 7, 1948, p. 60, data on production.

the weight of three passengers. This is a practical matter of importance since car testing must be standardized with some arbitrary load, such as the weight of a driver, or the driver and one passenger, and so forth. Whatever condition is standardized will be different from the loading that exists in many of the same cars when on the road.

The small variation in weight between most cars simplifies simulation of road loads on a chassis dynamometer, for acceleration time. It justifies building sufficient mass in the traction wheels to be equivalent to the mass of an average car. The acceleration of the average car will then be the same as on the road. The acceleration of cars with weights differing from the average will deviate from the accelerations on the road by quantities no greater than their deviations from the average weight. This may be corrected by multiplying the

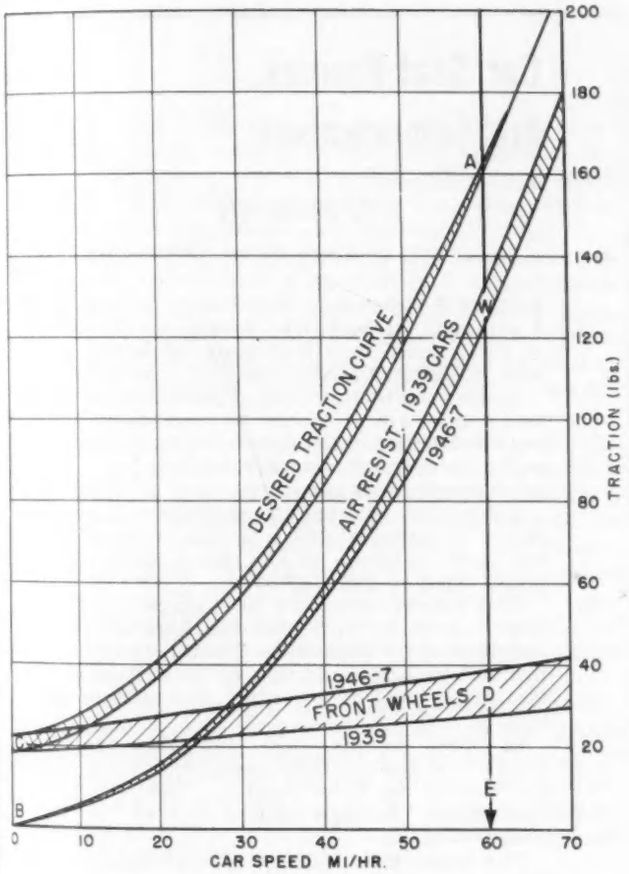

Fig. 2—Air and front-wheel resistance of average cars

acceleration time by the ratio of the equivalent chassis dynamometer mass to the car mass. Such correction for weight deviations up to 25%, or about 800 lb, appear acceptable and are believed to justify the mechanical simplicity of a fixed built-in mass rather than adjustable masses with clutches. Furthermore, it is believed that where the mass is built in the traction wheels, it becomes an important factor in minimizing the wear on gears, universal joints, and so forth, because of reducing shock loading on these parts.

Traction Wheels

The size of the traction wheels has frequently raised discussion. Those used by the Automobile Club had a circumference of 1/300 of a mile, so that 300 revolutions represented one mile. The diameter was, therefore, 5.60 ft, or 67¼ in. This size has been used on many later designs, including one at the

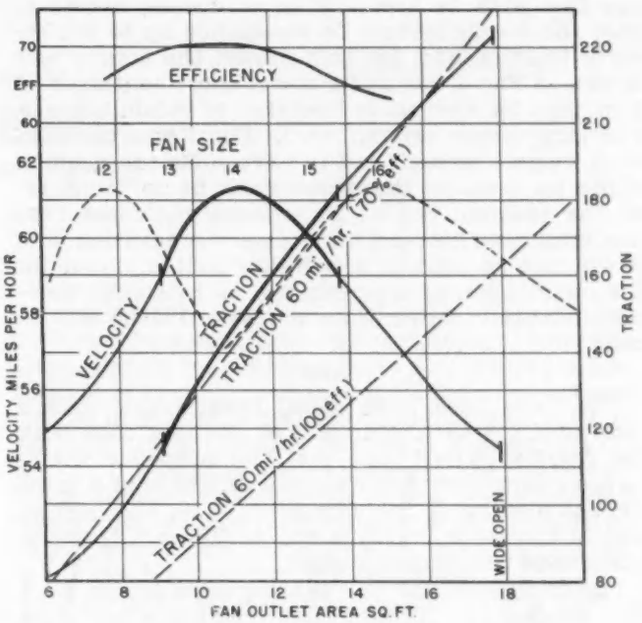

Fig. 3—Characteristics of blower at 234 rpm, in terms of air speed and traction, as affected by outlet area

U. S. Bureau of Standards. Several tire manufacturers use this size because it is required for certain U. S. Government tests for tires, although they seem to prefer testing on wheels 10 ft in diameter or larger. Obviously, the smaller the wheel, the greater will be the tire flexure and increase of rolling resistance above that resulting on the road. Also, the more serious will be the error in traction readings when operating with the tire a little off the center of the wheel. Furthermore, a smaller wheel would make difficult the use of a rim of sufficient mass to approximate the mass of a car. One more point in favor of the large wheel is the increased area for cooling. It is recognized that smaller wheels may reduce the size of the pit required under the floor, but, where this is not a critical limitation, the 5.6-ft diameter seems to be a conservative value. The wheels used have a width of 20⅜ in. and are spaced on 4-ft 9-in. centers, so that cars may be tested with treads from at least 43 to 70 in.

These traction wheels follow the example of the original Automobile Club construction. They are made of compressed paper between steel rims, made thick enough to supply the desired inertia mass. This material gives a very satisfactory traction sur-

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face, and may be prevented from softening by water absorption by periodic coating with shellac. We are not in a position to advise from experience if steel wheels would prove more satisfactory, but it is believed that they are considerably more expensive, and may not supply as good traction if allowed to become greasy.

Calibration of the traction scale is accomplished by wrapping a steel tape around the traction wheel and attaching test weights. This is a simple, straight-forward test. By reversing the tape so that the weights are applied on the opposite side of the wheel, a check is obtained on any reverse linkage that may be used. It is, of course, necessary that the torque system be in balance up to the reverse linkage, and for this reason the torque arm shown in Fig. 1 has at its end a short container of 2-in. pipe for washers or lead shot to obtain balance. The long torque arm shown in Fig. 1 was provided with weights at each end to have sufficient moment of inertia to assure that there would be no "hunting" of the traction scale. Experience indicates that this may have been an unnecessary precaution, and it will not be used in a redesign contemplated for the installation of a pneumatic or hydraulic traction indicator, rather than the weight scale now in use.

Axles

The axles used have spiral bevel gears, with a ratio of 4 5/9 to 1. In spite of the fact that both the traction wheel axle and the propeller shafts turn opposite from their normal direction in a vehicle, the loading of the axle gears is on the normal face of the teeth. This is due to the fact that the axle drives the propeller shaft.

The friction of the ball bearings and grease seals that support or "cradle" the traction-wheel axle causes an error in all traction readings, since it is subtracted from the true reading on increasing loads and added on decreasing loads, thus causing an hysteresis loop. This is similar to the error in typical electric cradle dynamometers, caused by friction of the bearings, which "cradle" the field frames. The value of this friction is very low however, being about 2 lb on the traction scale. This is about 0.2% for the normal maximum traction load of 1000 lb and only 2% at traction loads of 100 lb. Where such errors are considered excessive, they may be minimized by slowly rotating the outer races of these two bearings in opposite directions. This has been done in at least one chassis dynamometer installation, but appears to be an unnecessary complication in most car testing.

The friction of all other parts of the axle and drive system make up an irreducible load on the test scale. The traction-wheel bearing friction results in a traction load of only about 1 lb for each wheel at 1 mph. The total up to the generator is hardly any greater at this speed, increasing to about 6 lb at 60 mph, as indicated by "motoring." When driven by a car in low gear, at 1-2 mph the friction load totals about 14-18 lb, the increase being due to generator brush friction, fan belts, and so forth.

Summary

The foregoing examples indicate the general utility of a chassis dynamometer in studying many of the features of automobile design that affect the fuel and oil required for good performance. It is a device that not only offers more convenience in conducting tests than runs on the road but also it has additional advantages, such as reproducible temperatures and continuous measurements of power developed. Other factors of importance are those of offering the equivalent of unlimited straight and level roads for acceleration or continued high-speed runs well above legal speed limits on highways, and performance on simulated hills of any desired gradient. This is a great convenience, since such hills are surprisingly difficult to find when desired for test runs.

After 17 years' experience with equipment of this type it has been found invaluable in adjusting the manufacture of petroleum products to meet the changing conditions imposed by the year to year evolution in automobile design.

Car Seat Frames Are Compromises

Based on paper by

J. E. BRENNAN

Dodge Division, Chrysler Corp.

TODAY'S automobile seat frames have a minimum in bulk and weight to allow as much space for the motorist as is possible in low sleek automobile body contours.

Hence construction of most passenger car seat frames are of tubular or steel stamping construction, which are stronger, wider, and more compact than the earlier wooden or composite seat structures.

Tubing has inherent strength difficult to obtain in other designs, although they are less easily adapted to the more conventional types of trim fastenings.

This consists primarily of a single steel tube shaped to form both the horizontal and vertical portions of the frame. This is fastened to the base or seat guides through the tubing itself or by welded steel stampings.

In other designs, steel stampings are welded into the complete assembly. These can usually be more compact, and save some space. In some designs 50% of the steel is scrap.

The latter material also permits panels of the seat frame to serve as a foundation for the trim, and can be so designed as to anchor the trim material by perforations or shaping.

Seat framework must be economical, safe, easy to manufacture and to trim, and must meet requirements of the spring and trim designer as well. (Paper "Seat Frames" was presented at the SAE National Passenger Car, Body, and Production Meeting, Detroit, March 8, 1949. Copies are available from SAE Special Publications Department. Price: 25¢ to SAE members, 50¢ to nonmembers.)

Cold Rubber Is A Hot Material

BASED ON PAPER* BY

L. M. Baker

Mansfield Tire & Rubber Co.

COLD rubber promises to pre-empt the rubber market, if enough of it becomes available, because it has better properties than GR-S synthetic, although made of about the same materials, and in some respects surpasses natural rubber.

While consisting of essentially the same ingredients as standard GR-S, cold rubber (a copolymer of butadiene and styrene) is made at reaction temperatures much below the standard processing temperature of 122F. Present plan is to make most of it at about 41F, although it can be produced at as low as zeroF.

Higher temperatures normally must be used with GR-S to get satisfactory conversion or polymerization within a reasonable reaction time. Discovery of activators to speed up polymerization rate at low temperatures made it possible to make cold rubber.

It is this "cold" processing that imparts the superior qualities to the rubber. This manifests itself when comparing the new material and conventional rubbers as to tensile strength, resistance to aging, hysteresis, flex life, and tread wear.

Cold rubber products containing reinforcing pigments show tensile strengths and elongation values much greater than standard GR-S and, in some cases, even better than natural rubber. Even without reinforcing ingredients cold rubber is superior in tensile strength to GR-S, but its properties are lower than those of natural rubber.

Aging cold rubber products degrades physical properties less than similar products containing standard GR-S or natural rubber.

Hysteresis loss for cold rubber products is much lower than those made from GR-S, but somewhat higher than for natural rubber. This means that tires made of cold rubber run cooler than standard GR-S tires, but not quite as cool as those containing natural rubber. However, cold rubber tires give superior performance, although operating at temperatures slightly higher than those for natural rubber, because of greater resistance to oxidation resistance.

Most outstanding feature of cold rubber is its resistance to flex cracking and crack growth. In this respect it surpasses both GR-S and natural rubber. When reinforced with some of the new high-abrasion carbon blacks, cold rubber in tire treads has shown remarkable resistance to flex cracking and to growth of small cuts to large cracks.

Its abrasion resistance makes cold rubber a better tread-wearing material than crude and GR-S. This combination of improved abrasion resistance, better flex life, and crack-growth resistance will give the motoring public greater safety and more mileage from its tires.

The Rubber Reserve now sells cold rubber at the same price as GR-S, although it does cost a fraction of a cent per pound more to produce. While cost of materials is slightly lower, need for refrigeration and the lower volume of production tends to outweigh the savings in materials.

Cold rubber's future seems bright. Here is how it looks right now:

1. Because of its quality it will replace present standard types of GR-S, especially for tires.

2. As long as the market price of crude rubber does not dip much below the price of cold rubber, the new material will replace substantial quantities of crude. This will hold for quality products, even though natural rubber sells at a somewhat lower price.

3. Demand for cold rubber will not be met by the present conversion program for 198,000 tons annually. Conversion of other plants probably will be authorized when the present program has been completed and it has been demonstrated that cold rubber demand exceeds supply. Until cold rubber supply is greater than the demand for it as a GR-S replacement, there will be little replacement of natural rubber, resulting in little increase in total demand for chemical rubber.

* Paper "Cold Rubber," was presented at SAE Pittsburgh Section, Jan. 25, 1949. (This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

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THINGS to KNOW about

EXCERPTS FROM PAPER* BY **R. V. Hutchinson** Central Engineering Group GENERAL MOTORS CORP.

VALVE gear designers shoot at a three-goal target:

1. To provide a satisfactory, durable, and quiet mechanism.
2. To lead the working fluid through the engine without waste.
3. To do these things within a given cost.

Silent operation is not essential to overall durability. Too much silence often coincides with need for frequent overhaul. But noise may be the symptom of an unhealthy condition as well as a desirable one.

There are two kinds of valve gear noises—clicks and rustles.

Clicks follow impacts—as between lifter or rocker tip and valve stem on opening, or valve head and valve seat on closing. They usually occur at start and finish of valve motion. But worn rocker-operated gear can and do click at intermediate stages.

Rustles generally give evidence of impulsive loadings, following sudden changes in acceleration-time relationships. This noise generally stems from valve springs and, at times, from push rods.

When operating at speed, valve motion is not precisely what kinematic studies would indicate; mass and elasticity of the parts introduce phase and amplitude changes, altering the relation between impressed and consequent motions.

For example, on side-valve engines, camshaft flexibility exerts considerable influence on phase and amplitude changes. If the design permits multiple bearings, halving the span between them has about the same stiffening effect as a two-thirds increase in diameter.

In push-rod overhead-valve engines, the camshaft bends, push-rods buckle, rocker brackets yield, and rocker shafts and rocker arms bend to some extent. This is not evidence of unsatisfactory design. It may have been forced by a cost budget. Flexible valve gear with compensating cam shape is commercially good until valve seat maintenance becomes excessive, or valve gear motion is wild enough to cause undue noise, power loss, or parts breakage.

Valve Timing

The designer aims to achieve his second objective by proper valve timing. If the engine had any choice, valve timing would vary with speed and load. The throttle is a density charger. Mean gas velocity in the manifold is almost independent of throttle opening. The throttle controls the mass flow rate of working fluid the engine can take at a given speed.

For all speeds and loads, it would be desirable for all valves to open and close at times most suitable for desired directions of flow. The working fluid has mass and elasticity. Being in motion, it attains favorable pressure relationships at different cycle times as speeds and loads are varied.

We don't know how to make a satisfactory infinitely variable valve gear. And even if we had one and could afford it, we do not know enough about our engines to use it.

But we do know a few things to be generally true. For example, too early intake opening, because of exhaust backflow, can spoil idle to the point of stall. Too late intake closing permits feedback into the intake at moderate speeds, before the valve seats.

However, this is not fundamentally bad because the engine is effectively throttled at moderate speeds by valve timing. Without too late a spark, it may permit the use of lower octane fuel in the medium speed range. This may be the objective in trying to use a high compression engine for its high expansion ratio feature—for part-load economy.

Late exhaust closing—with free exhaust—always improves high-speed scavenge, and with it power. With some exhaust systems, pressure surges may feed back and discourage scavenge. When many cylinders discharge into a single pipe, this is to be expected in the operating range and may contribute to the formation of dips in the torque-speed curve.

Early exhaust opening reduces expansion ratio, and with it—to some extent—fuel economy. The valves are opened against higher pressures and temperatures, actuating forces are greater, and valve seat failure is encouraged.

But early openings and late closings do increase time of opening and slow down acceleration changes, if properly used. Thus impulsive loadings, surges, and rustle can be reduced.

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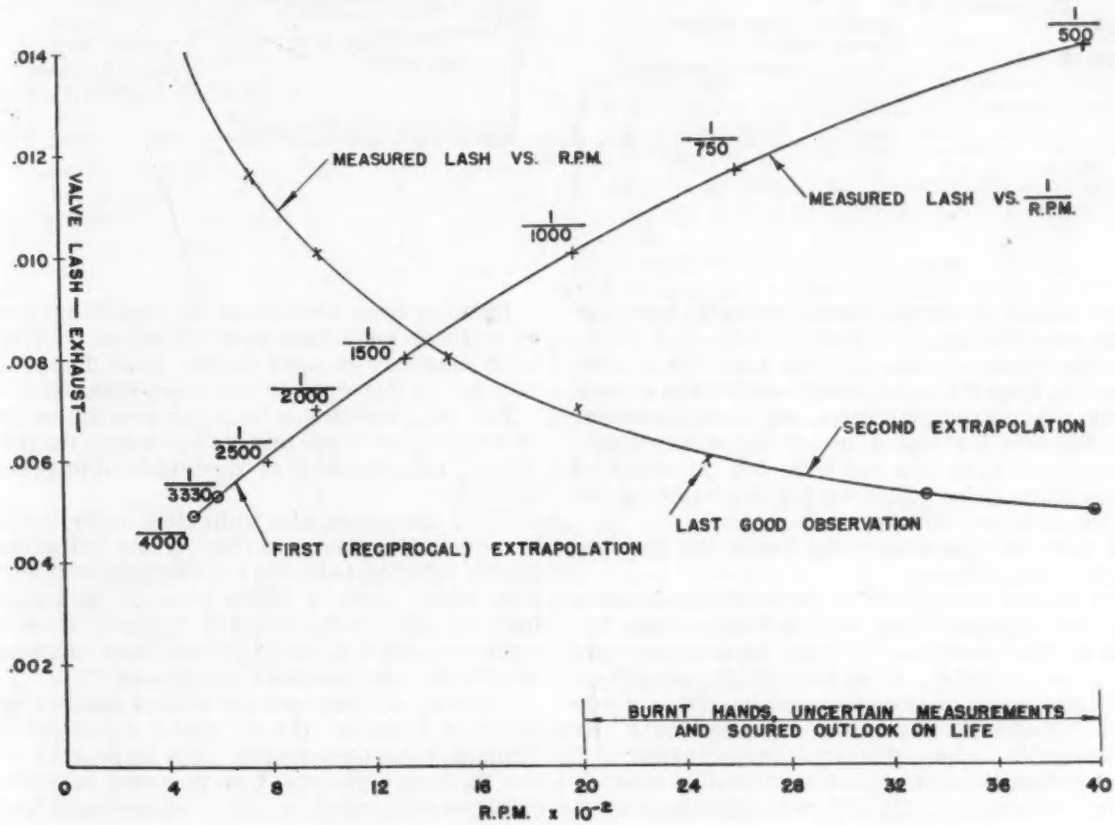
* Paper "Random Notes on Valve Gear," was presented at SAE Western Michigan Section, Muskegon, Sept. 23, 1948. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

VALVE GEAR DESIGN

So long as resonances are avoided, reduction of valve opening duration imposes conditions analogous to a change in rotational speed. For example, reducing opening angle from 250 to 230 crank deg is about the same as increasing the engine speed by 100% $[(250/230)^2 - 1]$, or say 18%, so far as potential impulsive loadings are concerned. This complicates the job of designing valve gear for smooth operation at high engine speeds, using short duration timings favorable to part-load economy.

(Following is a discussion of a few detailed considerations in design of valve gear components.)

1. Valve Lash Variation



This is a plot of stabilized exhaust-valve lash versus speed at full throttle for a side-valve engine. At speeds above 2500 rpm, feeler measurements often are unreliable for numerous reasons and extrapolation is justified. To improve precision of extrapolation, it is better to plot lash versus reciprocal of speed, as shown. Now look at the following illustrations to see how we got these data.

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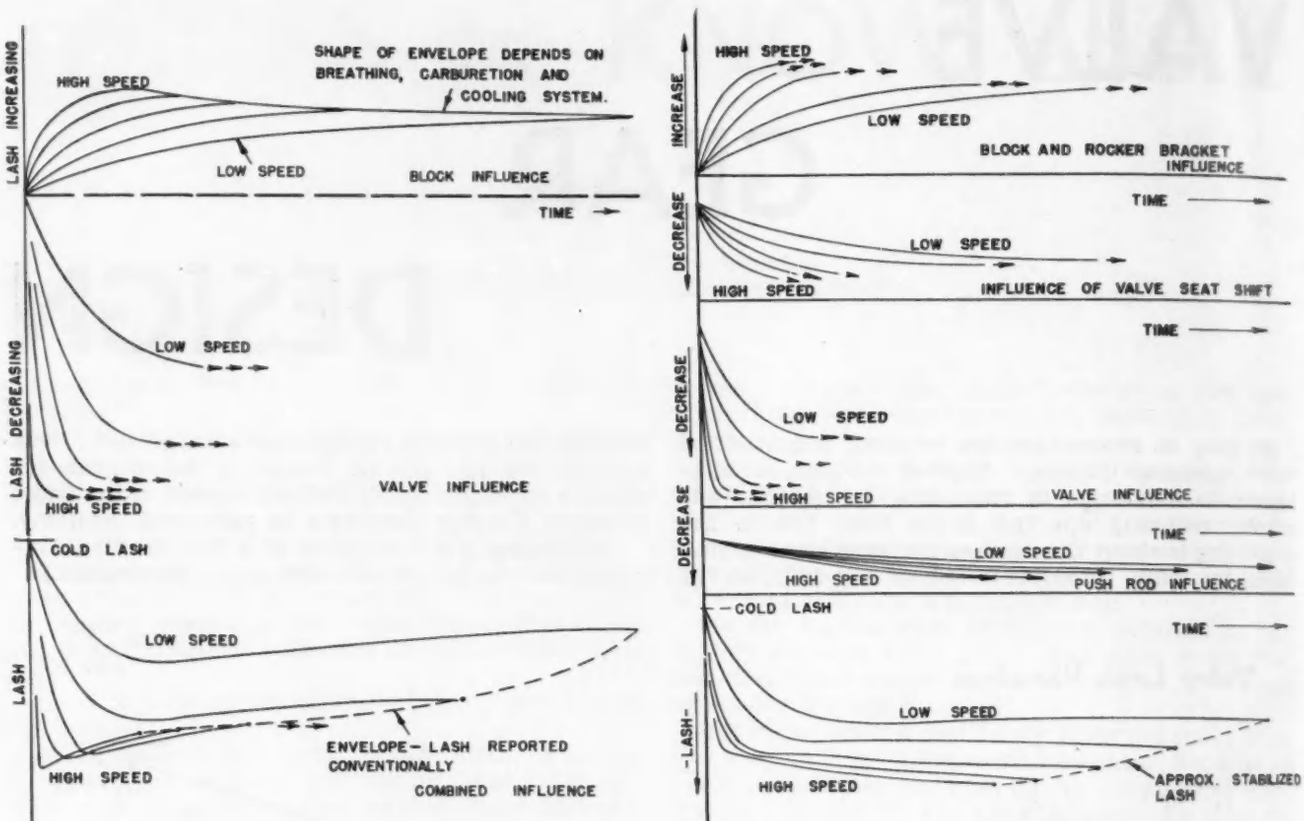
2. Typical Exhaust Valve Transients



These charts illustrate how exhaust lash approaches equilibrium at steady speed and loads. Note in the chart at left, typical data for a side-valve engine, that if the valves are lashed too closely, they may ride during warmup, yet have clearance when stabilized. Data at right are for an overhead-valve engine, a push-rod job with top oil returned down the push-rods. Observe the slow-acting influence of push-rod changes.

These data are plotted with arrows to indicate substantial equilibrium.

Taking factors that affect lash change one-by-one, we find that exhaust valve length changes are influenced by the following: thermal expansion characteristics of material; valve seat angle; length of exposed neck; ratio of exposed neck length to guide length; ratio of stem diameter to guide length; fit of stem in guide; and valve neck temperature.

Valve head expansion causes the head to ride up the conical valve seat, slightly retracting the stem in the guide. Aside from efforts made to mask the neck with extended valves guides, length of the exposed neck largely is established by core-setting requirements. Ratio of exposed neck length to guide length is roughly the ratio of heat-absorbtion surface to heat-dissipating surface of the stem.

Ratio of neck absorbtion surface to sectional area of endwise heat-flow path increases inversely with stem diameter of solid valves; heat-dissipating surface in the valve guide increases directly.

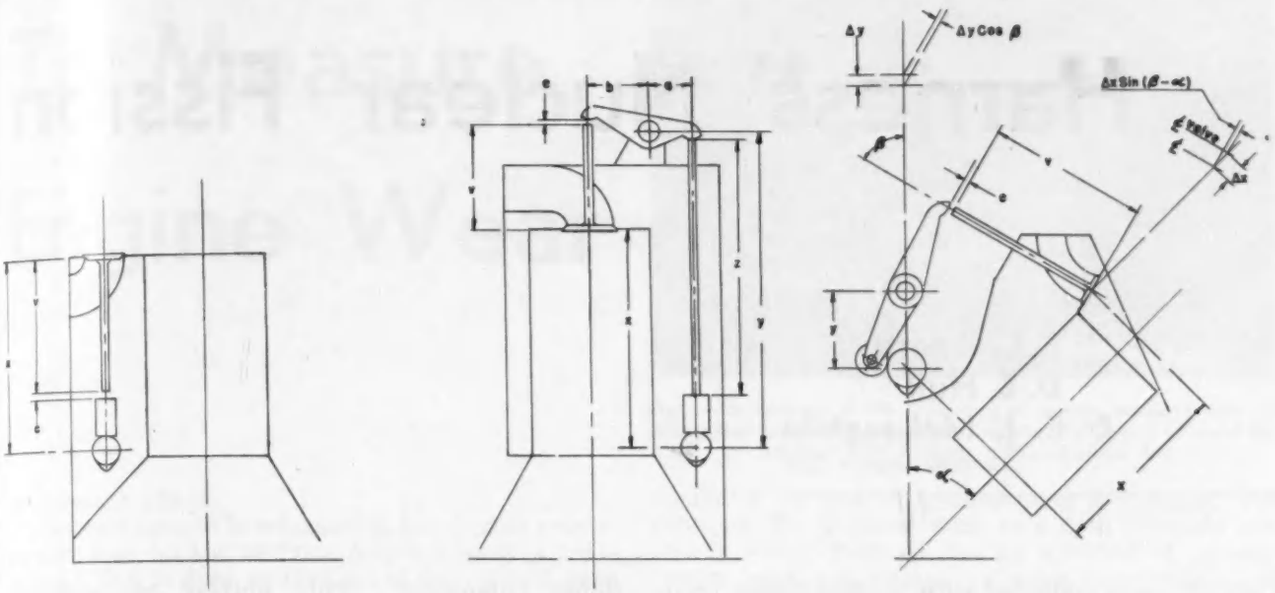
For comparable fits, both the average temperature of an exhaust valve and its operating length will be almost independent of moderate changes in stem diameter.

Some measurements indicate a valve temperature increase after the guide has worn; but without any simple relation between the variables. Such indication would seem to follow changes in surface conformity. As such, it could initially show lowered temperatures with start of wear and increased temperatures later as wear progresses.

Valve neck temperatures reflect exhaust gas temperature to some extent. When measured with extinction-type pyrometers, they appear to be sensitive to these elements: fuel flow rate per unit engine displacement, mixture ratio, compression ratio, and expansion ratio. Greater fuel flow rates and leaner mixes seem to increase neck temperatures. Higher compression and expansion ratios—at full-throttle operation—reduce neck temperature.

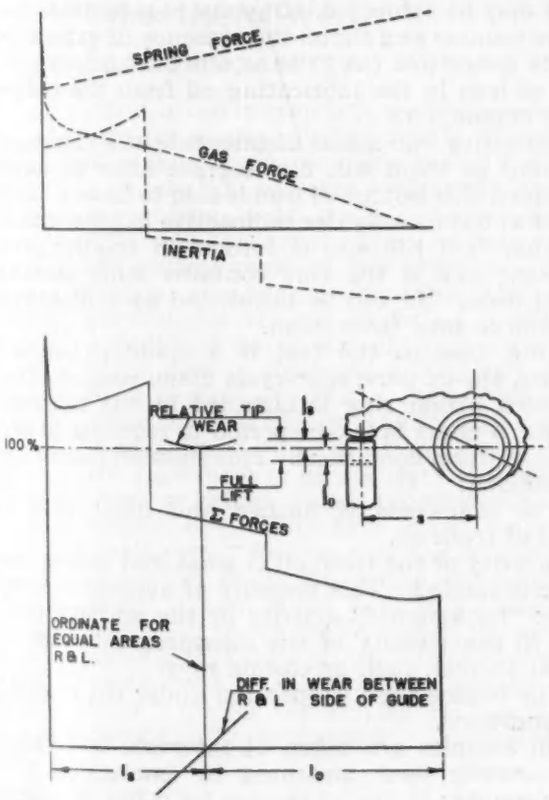
Block influence depends on extent of jacketing, freedom from liming, and location of the valve seat.

3. How Lash Changes with Temperature


TOTAL LASH CHANGE
$= \Delta x - \Delta v$
TOTAL LASH CHANGE
$= \frac{b}{a}(\Delta y - \Delta z) - (\Delta v + \Delta x)$
TOTAL LASH CHANGE
$= \Delta x \sin(\beta - \alpha) - \Delta v + \Delta y \cos\beta$

Shown here are typical constituents of lash changes with temperature for three basic engine configurations. For steady speed and loads, all components change exponentially with time at various rates.

4. Rocker, Valve Tip, and Guide Relationships



One approach to choice of relative position of rocker and valve is to proportion the parts to:

1. Give minimum friction work between rocker end and valve tips, and
2. Equate friction work between stem and guide due to forces acting in each direction normal to the valve axis.

Motion between rocker end and valve tip is combined sliding and rolling. Sliding vanishes when a line through the rocker axis is simultaneously tangent to the rocker tip and normal to the valve axis. Because of friction drag between rocker end and valve tip, side forces are set up between valve stem and guide; these forces reverse direction as valve tip sliding vanishes and the motion is pure rolling for the instant.

When valve guides are fairly long and overhang of the stem end moderate, guide conditions at the outer end only need be considered. For this setup, the following method gives good results in locating the rocker shaft:

For any given engine speed, plot the algebraic sums of gas load, spring load, and inertia forces acting to press together valve tip and rocker against valve position during opening. (This is shown above.) The ordinate equally dividing the area under this plot locates the valve lift at, or close to, the place where rocker tip motion should be pure roll to equate work lost in guide friction.

Since potential guide wear is consequent to work lost between rocker and tip, it turns out when parts are proportioned for equalized guide friction losses, then valve tip/rocker losses approach minimum values. Thus, proportioning for good guide life enables good valve tip and rocker geometry.

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Harness Nuclear Fission

BASED ON PAPER* BY **P. L. Pinotti**
D. E. Hull
& E. J. McLaughlin
California Research Corp.

ENGINE parts activated with nuclear fission products in an atomic pile yield accurate and reproducible wear measurements in 2 to 4 hr instead of the usual several hundred hours of testing time. Fuel and lube oil samples are much smaller than in conventional tests and engine disassembly between tests is eliminated. But irradiated piston rings and activated oil must be handled with care.

Examination of conventional wear-measuring methods helps point up advantages of the radioactive tracer technique.

Normal wear test method is to assemble the test engine with new or cleaned pistons, rings, cylinder liners, and bearings after these parts have been carefully weighed and measured. The engine then is operated for an extended period and dismantled for inspection. This includes visual observation and rating, measuring, weighing, and photographing.

In some cases the engine is disassembled several times during the test run for additional inspections. But to get desired accuracy usually requires several hundred hours.

This type of test is slow and expensive because of the length of the test. Intermediate disassembly sometimes produces erratic results. And results are influenced by surface finish of parts used in successive tests. Variations in new parts used greatly affect precision.

The new radioactive-tracer method measures wear by determining, with a Geiger counter, the amount of radioactive metal, removed from the engine part under study, that is in the lubricating oil. In our work the top compression ring was selected for initial study.

Radioactive rings are produced by irradiating ordinary cast-iron piston rings in the atomic pile at the Atomic Energy Commission's Oak Ridge National Laboratory. This nuclear bombardment makes a small fraction of the iron atoms in the ring radioactive—about one in a billion. Atoms absorbing the neutrons are changed to atoms of a heavier iron isotope. The heavier iron isotope is almost identical with the original iron in all properties except radioactivity.

The heavier iron atoms emit beta and gamma rays spontaneously during radioactive disintegration. This process, like other radioactive decompositions, goes on at a rate independent of temperature and any physical or chemical treatment to which the metal may be subjected. Gamma rays activate the Geiger counter and signal the presence of extremely minute quantities (as little as one part in ten million) of iron in the lubricating oil from the radioactive engine part.

Radioactive iron atoms disintegrate at a rate such that half of them will disintegrate after 47 days. Therefore, this isotope of iron is said to have a "half life" of 47 days. A lighter radioactive isotope with a four-year half life also is formed in smaller proportions. And if the ring contains other metals, overall decay life will be influenced by radioactive elements formed from them.

Engine used in the test is a standard single-cylinder, 4¼-in. bore, four-cycle diesel engine. The irradiated piston ring is installed in the top ring groove. A short break-in period is required to establish uniform conditions. This six-step procedure then follows:

1. The crankcase is flushed and filled with a charge of fresh oil.
2. Activity of the fresh oil is measured before the engine is started. This measure of activity is used for the "background" activity or the activity that exists in the vicinity of the measurements due to natural sources, such as cosmic rays.
3. The engine then is operated under the desired test conditions.
4. Oil samples are taken at intervals and radiation activity level measured by immersing the Geiger counter in the oil sample for a few minutes,

* Paper "Application of Radioactive Tracers to Improvement of Automotive Fuels, Lubricants, and Engines," was presented at SAE National Passenger, Body, and Production Meeting, Detroit, March 8, 1949. (This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

To Measure Engine Wear

Fig. 1—Radioactivity of the lubricating oil sample, measured with this Geiger-Mueller counting equipment, indicates the amount of metal that has been worn from the irradiated piston ring

as shown in Fig. 1.

5. The oil sample is returned to the engine crankcase as soon as the activity measurement is completed. This is done so that all of the oil will have a uniform radioactivity level before the next sample is taken.

6. The radioactivity level of the oil varies directly with the amount and specific activity of the activated iron in the oil; thus, the amount of iron worn from the ring can be readily calculated.

Representative test results point up the reproducibility of this wear-measuring technique. For example, Fig. 2 shows wear rate data from six reference tests, obtained during a series of 19 successive tests in the single cylinder, four-cycle diesel engine. The narrow band which covers five of the six tests demonstrates the excellent reproducibility possible with these tests. The one reference test which does not fall in this band was influenced by a deviation in test operating conditions.

Table 1 illustrates effects of engine operating conditions on wear rate in the single-cylinder engine.

Other Useful Work For Atomic Energy

Industrial research is finding peacetime uses for nuclear fission that hold promise of making products cheaper and better.

In addition to using radioactive isotopes for engine wear measurements, as described in this article, they can help evaluate critical parts of transmissions, differentials, steering mechanisms, and other parts under various operating conditions.

Radioisotope tracers aid process control when used in thickness and height gages. Such devices are faster than mechanical gages, as one rubber manufacturer found in measuring thin rubber and plastic films. His gage reads to an accuracy of 0.00001 in.

As a height gage, radioisotopes have helped one automotive plant better its metallurgy. In this case the foundrymen could not easily determine the height to which molten metal rises in a cupola, because of the intense heat. By sending gamma rays through the cupola and measuring their intensity on the opposite side with a Geiger counter, actual liquid level can be easily determined. This makes for closer quality control of the metal and more efficient operation.

With isotopes of Cobalt 60 it is now possible to inspect thick metal sections. This radioactive material has a penetrating power equal to that of a 2,000,000-v X-ray machine. This technique is being used to make periodic checks of welds in high-pressure steam lines. Condition of each weld is recorded on X-ray film. Defective welds are easily detected.

Isotopes also aid in controlling thickness of steel sheets rolled in steel mills. Because this method offers substantial savings and better control of steel sheet sizes, one company is planning such an installation.

In another case radioisotopes have been put to work dissipating electrostatic charges on heavy machinery. Placing radioactive material near moving parts of the machine ionizes the air surrounding the parts. This prevents accumulation of an electrostatic charge.

In the petroleum field refiners find they can use radioisotopes to trace shipments through miles of pipe lines. And they also are learning what happens to petroleum molecules as they pass through the refinery process by using radioactive carbon.

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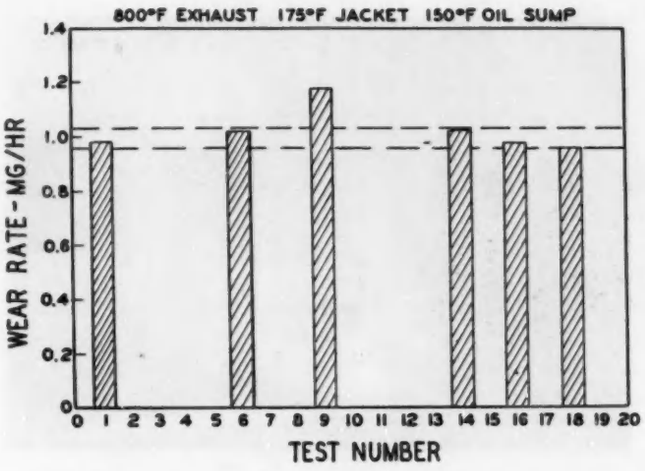

Fig. 2—Reproducibility of the radioactive tracer wear-measuring method is indicated by the results of six tests. Test No. 9, which does not fall within the narrow range shown as the other five do, varies because of a deviation in operating conditions. These tests were run on a single-cylinder, four-cycle diesel engine with a 4¼-in. bore

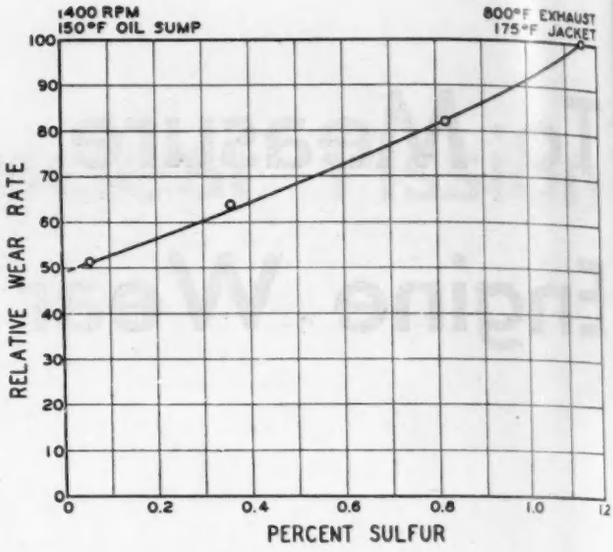

Fig. 3—Wear tests with radioactive piston rings show that wear varies directly with diesel fuel sulfur content

Note that decreasing the jacket temperature substantially increases wear. And for the higher wear condition, decreasing engine output reduced wear.

These results depict the ease with which the method provides a complete picture of the effect of operating conditions on wear rate for a particular engine.

Wear rates obtained with compounded and uncompounded lubricating oils also were investigated. Typical results are shown in Table 2. It is interesting that wear rate of piston rings for heavy-duty service, as measured by the radioactive tracer method, is greatly reduced with superior oils, as extensive laboratory and field tests already have proved.

Effect of fuel sulfur content on ring wear (of concern to both engine builder and oil refiner) was determined by this new method in one day, for one engine, under specified operating conditions. These data, as shown in Fig. 3, indicate consistent increase in wear rate with increased sulfur content. This agrees with published reports.

Safety Measures

In conducting these radioactive tracer tests, certain precautions should be taken for protection of operating personnel. About 100 milliroentgens per day is considered the maximum safe daily exposure from a health standpoint. The roentgen is a quantitative measure of the radiation exposure. One roentgen is the quantity of ionizing radiation which will dissipate 83 ergs in ionization per gram of body tissue.

The one-tenth of a roentgen, or the safe level of 100 milliroentgen, is the most activity which any individual worker should absorb in an 8-hr period.

Strongest source of radiation in our work is the rings themselves. These rings are stored and shipped in a 300-lb lead box. Highest surface radiation level measured on this box when it contains a full set of freshly-irradiated rings is about 7 milliroentgen per hr. Even if one person were to be in contact with the box for a full 8-hr period, his maximum exposure would be only 56 milliroentgen, or about half the safe tolerance level.

Rings being installed or removed are never touched by hand. They are handled with a set of long tongs or tools. Assembly and disassembly of the engine is carefully planned so that the work may be done in the least time. By taking the proper precautions, the mechanic who assembles the engine with the irradiated rings receives a total exposure, in the one to two-hour period, well within the safe limits.

All personnel working in the "isolation ward," or portion of the laboratory assigned to engines on this project, must wear radiation exposure meters.

Table 1—Effects of Engine Operating Conditions on Wear Rate

Jacket Temperature	Load, %	Wear Rate mg Iron per hr
180F	100	0.48
125F	100	0.83
125F	40	0.45

Table 2—Wear Rates Obtained with Compounded and Uncompounded Lubricating Oils

	Wear Rate mg Iron per hr
Uncompounded Oil	1.81
Heavy-Duty Oil Meeting Army Ordnance Specification 2-104B	1.06
Heavy-Duty Oil Meeting Caterpillar Tractor Series 2 Requirements	0.65

Canadian—June 23

Westmount Golf and Country Club, Kitchener, Ont., Can. Annual Golf Tournament. Hosts: Dominion Rubber Co. Ltd. and B. F. Goodrich Co. Ltd.

Central Illinois—June 13

Jefferson Hotel, Peoria, Ill.; dinner 6:30 p.m. Gear Design—Earle Buckingham, professor of mechanical engineering, Massachusetts Institute of Technology, and outstanding world authority on gears.

Cincinnati—June 24

Clovernook Country Club; dinner 6:30 p.m. Summer golf meeting.

Cleveland—June 24

Chagrin Valley Country Club. Annual Golf Outing and Dinner.

Metropolitan—June 16

Statler Hotel, New York, N. Y.; meeting 7:45 p.m. Present and Future of the Stratocruiser (illustrated with slides)—D. B. Martin, Boeing Aircraft Co. Movies of the XB-47 Stratojet.

Milwaukee—June 17

Ozaukee Country Club; dinner 6:30 p.m. Ladies Night.

Northern California—June 20

Alameda Naval Air Station; dinner 6:30 p.m. Jet Engine Maintenance—Speaker to be announced. Field trip in the afternoon to inspect the jet engine maintenance facilities.

St. Louis—June 14

Garavelli's, Inc., Adolphus Room; dinner 7:00 p.m. Meeting 8:00 p.m. Additives in Lubricating Oils—T. P. Sands, chief automotive engineer, Monsanto Chemical Co., St. Louis, Mo. Cocktails 6:30 p.m. (sponsored by Lincoln Engineering Co.).

Spokane-Intermountain—June 11

Spokane Hotel, Roundup Room; dinner 6:30 p.m. Social Meeting.

Williamsport Group—June 6

The Antlers Club, Williamsport, Pa.; dinner 7:00 p.m. Annual Ladies Night. Dinner will be followed by special entertainment and dancing. Music by Paul Knoff and his orchestra.

NATIONAL MEETINGS

MEETING	DATE	HOTEL
WEST COAST	Aug. 15-17	Multnomah, Portland, Oreg.
TRACTOR	Sept. 13-15	Schroeder, Milwaukee, Wis.
AERONAUTIC and Aircraft Engineering Display	Oct. 5-8	Biltmore, Los Angeles
DIESEL ENGINE	Nov. 1-2	Chase, St. Louis, Mo.
FUELS & LUBRICANTS	Nov. 3-4	Chase, St. Louis, Mo.
ANNUAL MEETING and Engineering Display	Jan. 9-13, 1950	Book-Cadillac, Detroit

STUDENT NEWS

University of Colorado

High-grade porcelain products require raw materials from many parts of the world, explained Charles Carpenter, production engineer for the Coors Porcelain Co., at the April 5 meeting.

Following the manufacturing steps in order, he told of the grinding and mixing of the clays and the methods used to form the material into the desired shapes. Included in the forming methods he described was the new isostatic method, which gives a product capable of being machined in its intermediate phases.

He told of the firing of the wares in carefully controlled kilns and of the need to allow for changes in dimensions during firing so that the final product is of the size desired.

In conclusion, Carpenter told of the outstanding physical properties of various types of porcelain and displayed several of the products made by Coors.

Fenn College

In analyzing what business wants from the engineer, James L. Myers, president of the Cleveland Graphite Bronze Co. stressed the fact that management wants technical knowledge plus junior-executive ability. Engineers must have the ability to analyze and make decisions, besides being able to judge people and assume responsibility, Myers added.

Since an executive must lead and direct, an engineer should be a self-starter and must have the highest character requirements, said Myers. No engineer will make a good executive unless he is able to select the proper men for specific types of work.

Myers also stated that most engineers today do not have enough interest in people and cannot adequately judge the human race. It is extremely unfortunate that a large number of engineers are unable to use the English language well, said Myers. He believes all technically trained men should be able to employ good, simple English persuasively.

However, industry finds satisfaction in that almost all engineers are very competent and are blessed with an excellent sense of direction. Myers emphasized that engineers have a strong sense of integrity, and are most dependable when assigned serious problems.

Myers spoke at the sixth annual Cleveland student-branch banquet, April 26, in which Fenn participated.

—R. L. Pappas, Field Editor

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Better Use of Transports

MORE exchange of information and more cooperation between its phases is a prime aim of the air transport industry today.

This became apparent at the SAE National Aeronautic Meeting where 400 engineers gathered for an all-day panel discussion on the airlines' new transports and to consider 10 technical papers, tour Curtiss-Wright Corp. plants, and hear Gen. Joseph T. McNarney detail United States' enterprise in aeronautic weapons.

Equipment makers want more data on flight operating conditions. . . . Airline operators need more and timelier service information. . . . And both groups seek cooperation on standardization and other technical problems. These desires overlaid all the more specific suggestions made at the panel discussion as well as at other sessions of the four-day gathering.

An operator poured out data to prove that maintenance specifications are too arbitrary for the new transports, and he invited cooperation of engine and accessories manufacturers to get liberalization. A review of life evaluation methods for aircraft structures emphasized that airframe designers need more data on load histories and material strengths. Even the passengers need more information, insisted airline safety experts who want evacuation techniques for emergency use publicized.

Added impetus for fullest exchange of information on the new transports sprang from one observer's prophesy that the airlines will be using the current crop of new airplanes for many years. He felt that jet transports are at least 15 years away. But he foresaw availability of turboprops for installation in existing airplanes within three years.

Developers of the new powerplants traded pointers on modifying B-17's for flying turboprop test beds, the good handling characteristics of nitromethane as a rocket propellant, and an extension of the Mentzer-Nourse formulas that evaluates powerplants in terms of operating costs. Carburetor specialists, still counting on piston engines for personal aircraft, reported that a new speed metering device may replace float-type carburetors.

As if in answer to some of the pleas made at the meeting for exchange of information, Curtiss-Wright Corp. conducted SAE members through experimental and production facilities for propellers at Curtiss-Wright Propeller Division. Guests even glimpsed firing of the rocket powerplant the corporation is completing for the new Bell X-2 research airplane.

Part of the curtain of security was lifted by General McNarney to give aeronautical engineers a glimpse of some of the long-range development work of the U.S. military establishment. The commanding general of the USAF Materiel Command and Secretary of Defense Johnson's coordinator of the military services promised that any potential aggressor would discover that this country will not use the strategy, tactics, and weapons of the last war.

He told his audience that the development program is pointed to superior equipment, and that pure research is being carried on by the National Advisory Committee for Aeronautics, 294 basic research contracts with 76 nonprofit institutions, and 67 basic research contracts with 52 profit organizations. These contracts amount to about $60 million, he reported.

"At the higher aircraft speeds, new capabilities must be built into optical and radar sighting devices. At 40,000 ft and speeds of 600 mph requirements for operation are virtually beyond the physi-

1—Talking over the meeting are the committee chairmen of the three activities sponsoring it: (left to right) R. C. Loomis, Air Transport Activity; Karl Arnstein, Aircraft Activity; and A. M. Rothrock, Aircraft Powerplant Activity

2—K. E. Van Every, winner of Wright Brothers Medal, accepts accompanying certificate from W. E. Beall

3—Reception preceding dinner brings together (left to right) SAE Metropolitan Section Chairman R. C. Long, SAE President S. W. Sparrow, dinner speaker Gen. Joseph T. McNarney, USAF, and toastmaster Ralph S. Damon

Sought at AERO MEETING

cal reactions of the human body." Hence, he said almost human thinking must be built into computers.

Discussers Trade Suggestions

Declared equipment makers to airline operators at the panel discussion: We can do more to help you get the most out of your new transports if you collect systematically, analyze, and relay to us more data on actual flight operations. With more data, we can come closer to the optimum combination of reliability, light weight, and low cost in replacement components for the new transports. Airlines engineering personnel are more valuable in analyzing flight data to find out why equipment fails and in taking up the failures directly with the manufacturers than in devising their own fixes, according to the manufacturers.

Operators were reminded that plenty of data exist on the cost of carrying an extra pound on an aircraft for a year, but none on the saving in extending a maintenance period. One propeller expert asked for data on the desirability of providing extra thickness in aluminum-alloy blades to prolong service life. If extra thickness is desirable, how great an increase in weight or sacrifice in efficiency is economical, he inquired, or how much is it worth weightwise to double the current overhaul period? And builders of generators and other accessories asked for vibration data on the engine-propeller combination.

Suppliers urged operators to make more use of service manuals and to send capable men to the service schools run by manufacturers.

Airlines men countered with requests for better service manuals, made available as soon as equipment goes into service or before. They complained that too often their requests for service information are ignored or the answers delayed. And they asked to be informed of what is "designed into" the equipment.

Equipment manufacturers recommended that the airlines get together on maintenance and standards. They suggested that the airlines set up an interairline maintenance organization for instruments and automatic equipment. Such mass production of maintenance could save money and do a better job.

Interairline standardization, manufacturers said, on such items as cockpit equipment, passenger equipment, windows, and doors, would be one of the most fruitful ways to cut costs on these items.

The airlines admitted that they hadn't made much progress in standardization, but, they said, neither have the manufacturers. More standardization among manufacturers on detail designs would greatly reduce operators' inventories of spare parts.

Suppliers told airline operators of imminent modifications they hope will improve the new transports. A carburetor manufacturer's representative spoke of new altitude compensation for carburetor idle systems to be ready next August that will prevent engine die-out at high altitude airports in going through propeller reversing. A starter manufacturer reported in production a new "turning unit" which turns the engine over slowly to make certain that no hydraulic lock exists within the system before the engines are started. By taking over this function formerly required of the starter, the turning unit eliminates wear and tear on the starter, its backer explained. An airframe manufacturer revealed plans to modify design of leading edges and

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fuselage nose sections, making them stronger and stiffer to withstand hail better.

And more improvements to existing aircraft were predicted: nonflammable hydraulic fluids, germicidal lamps and odor-control filters for air-conditioning systems, and even small gas turbine powerplants to supply heat and—maybe through hydraulic pumps and motors—power for pressurization and controls.

Warning On New Equipment

Interested as the airlines men were in these developments, they made it clear that they are more interested in having their suppliers get the bugs out of present equipment than in introducing new models which will undoubtedly present new troubles. The airlines urged maufacturers to concentrate on correcting deficiencies in and refining current designs.

Operators gave one other warning on designs for new equipment—they do not want complex automaticity at the expense of reliability. As one airline representative put it, "Anyone can devise an automatic gadget and compound it with another to make it fail-safe. The trick is to design so that neither will be required."

But one operator suggested two functions for which he thought it might be worth developing gadgets: a direct signal, actuated by the propeller, of propeller blade reversing, perhaps replacing the present device which shows merely when the electric circuit for reversing is complete; and constant speeding of propellers during reversing. By eliminating the dip in rpm of propellers passing through idling to reversing, constant speeding might help cure the engine die-outs due to overrichness now experienced at high-altitude airports and occasionally at sea level. Since the carburetor idle system supplies fuel flow at a rate constant with time, the higher propeller and engine rpm's would result in less rich mixtures. A carburetor expert agreed that constant speeding would help solve the carburetor problem.

Suppliers addressed a number of specific suggestions to airlines' maintenance engineers:

Eliminate T-buses in the electrical system—Substitute for T-buses separate feeders from each generator to a central main bus located near the pilot's or flight engineer's station. Provide each generator feeder to the main bus with differential current or balanced current protection and overvoltage protection. Arrange the relay to trip a circuit breaker in the feeder adjacent to the main bus. Clear only low values of fault current by opening this relay. Clear all other fault currents by the generator circuit breaker.

Run electric cable through ducts—Where wiring troubles are prevalent, run all cables and cable bundles through troughs or ducts instead of supporting them from hangers. Ducts simplify maintenance by improving accessibility and minimize the dangers of running electric cables beside hydraulic lines.

Consider a dual-fuel system—Since some aircraft engines do not need high-octane fuel for all flying conditions, consider cutting fuel bills by resorting to dual-fuel systems supplying either high-octane fuel or lower-octane fuel, as one large cargo operator has done. This airline found that instead of the 100/130 fuel normally specified for use in their war-surplus R-2800's, 91/98 fuel could be used for all low- and high-blower cruising conditions and even in 80% METO power climb in low blower.

Because of tankage and plumbing limitations, 91/98 fuel cannot be used in these airplanes as much as antiknock requirements permit. But by using about 60% 91/98 and 40% 100/130 gasolines, fuel cost has been cut 6% without any added maintenance troubles and without any damage resulting from mishandling of the dual system or mixing of fuels.

With more suitable tankage, fuel cost could be cut 10%. Altogether, this would amount to $1,000,000 on the airlines' annual $10,000,000 fuel bill.

Powerplant engineers disapproved of this dual-fuel idea. One pointed out that in well balanced engines, cruise- power bmep is established at a value just below the detonation range, so that cruising requires the same octane rating as take-off or climb. He added that in engines where cruising power is low enough to permit use of lower-octane fuel, when one engine fails, it will be difficult to get enough power out of the others on low-octane fuel.

The consensus of opinion was that whether or not dual fuels are practical for a given operation depends on the operator's ability to cope with added complexity and his philosophy concerning margin of detonation. It was agreed that use of the lower-octane fuel might reduce power and slow schedules somewhat.

Investigate possibilities of undercowl scoops—If induction system icing is a problem, investigate undercowl scoops. NACA has found them to have many advantages.

Plenty of data was presented to back up a plea to engine and accessory manufacturers to cooperate with airlines in inducing CAA to relax present maintenance regulations. Data on engines, propellers, and many items of equipments indicated that there is no correlation between length of overhaul period and number of premature removals.

Since failures do not increase with overhaul period and aircraft are maintained continuously anyway, it was argued that there is no reason for requiring overhaul at any given interval. Operators should be allowed to use their own judgment on maintenance, some believe, especially now that the new tranports are coming into use. They feel that eliminating costs of unnecessary overhauls and the attending loss of revenue during overhaul may prove the difference between profit and loss on operation of the new transports.

Lack of data on aircraft load histories is one of the factors named in a review of life-evaluation problems as preventing accurate estimation of the life of an aircraft structure. Also needed are data on fatigue characteristics of materials in the forms actually used in aircraft structures and a reliable theory for correlating life with loads.

Discussion revealed that the Air Materiel Command is filling in this gap in knowledge of load histories with data gathered on 90 flight analyzers installed in fighter, bomber, and cargo aircraft.

It was agreed that more data are needed on mag-

Panel on propulsion aspects of new transports grins at Chairman R. L. Earle's warning to heed "listeners' friend," small box near lecturn containing timing device and lights to remind speaker of time limit. Shown are (left to right) C. F. Baker, Hamilton Standard Propeller Division; H. G. Tartar, Bendix Products Division; P. D. Doran, United Aircraft Service Corp.; airlines "heckler" J. G. Borger, Pan American World Airways; W. V. Hanley, Standard Oil Co. of California; and Earle, Propeller Division, Curtiss-Wright Corp.

William Littlewood, general chairman for all-day panel discussion on "Getting the Best Out of Our New Transports," sums up discussion by representatives of airlines and manufacturers at close of evening session. Littlewood also opened discussion, paying tribute to late W. J. Blanchard, who conceived idea for all-day informal discussions and arranged first one for last October Aeronautic Meeting in Los Angeles

Members of morning panel search audience for next question on airborne equipment. Panel includes (left to right) P. C. Scofield, AiResearch Mfg. Co.; R. A. Brown, Minneapolis-Honeywell Regulator Co.; E. S. Gallagher, General Electric Co.; "heckler" J. B. Franklin, Capital Airlines, Inc.; and James Robinson, Vickers, Inc. Chairman, standing, is W. E. Beall, Boeing Aircraft Co.

At evening session summarizing day's discussion, panel members (left to right) D. E. Fritz, Jack & Heintz Precision Industries, Inc.; William Littlewood, American Airlines, Inc.; J. C. Leslie, Pan American World Airways; R. W. Young, Wright Aeronautical Corp.; and Charles Froesch, Eastern Air Lines, Inc., listen to A. E. Raymond, Douglas Aircraft, Inc. Panel chairman is Leslie

nitude and frequency of maneuver loads on all types of aircraft, and especially on jet aircraft where the possibility of gust loads being superimposed on maneuver loads is great.

Recognizing that accidents will continue to occur, due not only to structural or equipment failures but also to exhaustion of fuel supply in bad weather and collisions, men concerned with transport safety urged the airlines to educate passengers in emergency evacuation and survival methods. The feeling was that passengers are aware of the possibility of accident, as sales of trip insurance show. So giving them some information on what precautions are being taken and how they can cooperate in emergencies would be good public relations.

Techniques for emergency evacuation of passengers on land and sea are progressing, the safety experts showed. For example, several airlines have installed emergency chutes similar to playground slides which speed evacuation and deposit passengers away from the aircraft. The chute adapts to any airplane position, stows easily, and can be placed in service quickly.

Suggested for airport crashes was the use of a helicopter equipped with a loud speaker to direct evacuation of passengers. In case of fire, the helicopter could also discharge carbon dioxide.

New Transports To Have Long Use

The service afforded by the new transports pleases passengers so much that, although the cost of introducing the equipment has been tremendous, no major airline would be in business today if it had not converted, according to one observer. His review of recent air transport developments revealed

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Over 300 members and enrolled students responded to Curtiss-Wright Corp.'s invitation to tour their engine and propeller plants on the fourth day of the SAE Aeronautic Meeting. Guests spent the morning viewing WAC's experimental and production facilities. Standing near the end of an assembly line (left, center), they studied fine points of ignition-system installation. They inspected the shell of the Typhoon T-35 turboprop, (left, bottom) speculating on design details of the powerplant it will house.

After lunch at the WAC cafeteria, visitors boarded buses for the Curtiss Propeller Division. They watched through smoked glass the welding of the two halves of a propeller blade (left, top). Later they witnessed withdrawal of a blade with cherry-red shank from a heating unit in preparation for the upsetting operation (right, top).

that one major operator who had converted almost completely to postwar equipment began to show consistent profits in the last quarter of 1948 and has good prospects for continuing through 1949. Other operators, he warned, had better learn to live with their present new equipment because it will be a long time before they can replace it.

Finances, he believes, plus traffic control problems and braking difficulties will preclude use of jet transports before 1965. Braking will be a big problem in jet planes not only because there will be no propellers available to provide reverse thrust but, another speaker pointed out, new capacity and size requirements will be imposed on landing wheel brakes.

Landing speeds will be higher, adding to the braking load; and thin, high-speed wings will decrease the space available for housing landing gear. This will lead to high-load-capacity wheels of small size. Either more efficient brakes must be developed to fit within the small wheels, or other means of braking, such as an aerodynamic brake, will be needed.

Meantime, said the reviewer, turboprop control systems will be developed fast enough to make turboprops available for installation in existing airplanes, maybe within the next three years.

Future Powerplants Discussed

For flight-testing turboprops, both Wright Aeronautical and Allison Division use modified B-17 airplanes, it was reported. Modifications to WAC's B-17 included moving the cockpit rearward 4 ft, adding a fireproof powerplant bulkhead with mount attachment point just ahead of the pilot's and co-pilot's feet, reinforcing the fuselage structure back to a point in the tail where the necessary ballast in the form of bags of lead shot is located, adding a flight engineer's station in the bomb bay, and covering bomb bay doors with stainless steel fireproof skin.

WAC has found its flying test bed a highly successful vehicle for testing the T35 Typhoon. The B-17 offers safety, operational flexibility, and roominess.

Most obstacles to safe, simple, reliable operation of rockets stem from their propellants, engineers were told. Recommended to surmount the obstacles of handling difficulties was a monopropellant—nitromethane. This liquid, it was claimed, is stable over the range of temperatures and pressures likely to be encountered in handling. And its shock sensitivity is not a problem. Other advantages are its specific impulse of 218 sec, high specific weight, low vapor pressure, low viscosity, and very low corrosion rates. Besides, as a monopropellant, nitromethane simplifies plumbing.

As a criterion for selecting the best powerplant for a given transport, two researchers offered an equation expressing total operating cost of an airplane per payload ton-mile in terms of direct cost, payload costs, and overhead costs as constants of proportionality.

Discussers accepted the method as valuable in providing insight into the broad general problem of powerplant selection. But they listed other criteria which also must be considered in specific cases: safety, reliability, availability, climb-ceiling characteristics, take-off distance, and operation at other-than-optimum altitude. Warnings were voiced against considering the optimum altitude as a single level instead of a band and on the existence of strong winds at 35,000-40,000-ft altitudes, where they have not been expected.

There were indications that piston engines will continue to be the choice for personal aircraft but that the engines may have different fuel-metering devices. A new speed-metering unit was labeled a promising replacement for the simple float carburetor. Its backers explained that its metering ability is not affected by maneuvers or airplane attitude, it eliminates venturi icing and makes possible elimination of throttle refrigeration icing, and it has eliminated idle failures in glide.

Also reported under consideration for luxury personal airplanes is multiple-port injection, which improves distribution and alleviates the icing problem.

Based on discussions and 10 papers presented at five sessions under the chairmanships of **R. L. Templin, Jerome Lederer, D. J. Jordan, R. R. Higginbotham,** and **Major Raymond Hajek.** Papers "A Review of Problems in the Life Evaluation of Airplanes," **J. M. Jacobson,** Glenn L. Martin Co. . . . . "'On-Condition' Maintenance," **R. E. Geror,** Northwest Airlines, Inc. . . . . "Aircraft Evacuation on Land—Equipment, Stowage, and Procedure," **O. E. Kirchner,** American Airlines, Inc. . . . . "Developments in Search and Rescue," **Lt.-Com. A. W. Wuerker,** U. S. Coast Guard . . . . "Nitromethane as a Monopropellant," **F. Zwicky** and **C. C. Ross,** Aerojet Engineering Corp. . . . . "Flight Testing the Wright Typhoon Turbo-Prop," **R. R. Templeton** and **M. P. Cervino,** Wright Aeronautical Corp. . . . . "A Method of Evaluating Powerplants for Use in Subsonic Transport Airplanes," **H. M. Henneberry** and **A. F. Lietzke,** National Advisory Committee for Aeronautics . . . . "Fuel Systems and Carburetors for Personal Aircraft," **S. B. Smith, A. J. Volz,** and **M. R. Balis,** Bendix Products Division, Bendix Aviation Corp. . . . . "Review of Transport Aircraft Developments During the Past Two Years and Some Predictions for the Future," **R. C. Loomis,** Consolidated Vultee Aircraft Corp. . . . . "Landing Gears—Past, Present and Future," **T. J. Baker,** Air Materiel Command, Wright Field. . . . . All of these papers will appear in abridged or digest form in forthcoming issues of the SAE Journal, and those approved by Readers Committees will be published in full in SAE Quarterly Transactions.

■

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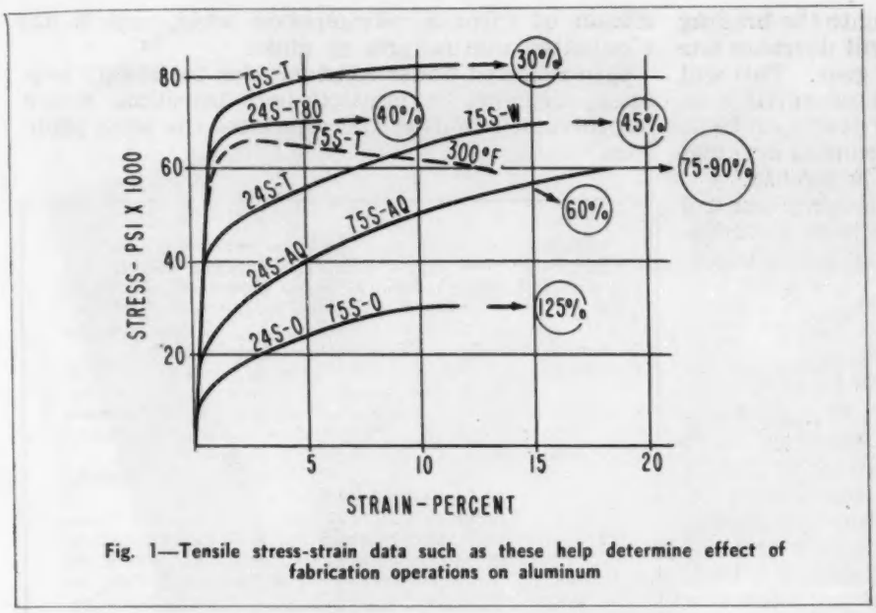

Fig. 1—Tensile stress-strain data such as these help determine effect of fabrication operations on aluminum

Manufacturing and Physicals Of Aluminum Go Hand-in-Hand

Based on paper by

O. A. WHEELON

Douglas Aircraft Co., Inc.

(This paper will be printed in full in SAE Quarterly Transactions)

EFFICIENT aircraft production demands closer attention to fabrication characteristics of aluminum alloys since they influence physical properties of the material.

Old criteria of ultimate tensile strength, yield strength, and elongation in 2 in. are not much good. Designers need a full range stress-strain diagram. This tells them the stress level at any amount of strain as well as something about the work-hardening characteristics and critical necking strain in simple tension. Designers also must know the local elongation at fracture (sometimes called the zero gage length elongation) since this criterion governs many fabrication operations—such as dimpling and bending.

These data are plotted in Fig. 1. The curves stop at the point where necking begins and end points are uniform elongations. Encircled figures give obtainable zero gage length elongation.

Also we must know the effect of complex stress systems, such as biaxial tension, both balanced and in the ratio of two to one, as in bending wide sheet. Fig. 2 shows a sample of 75SO 1/8-in. sheet, bent to fracture, which illustrates the difference in fracture strains for simple tension (square) and biaxial (wide) stress states. With this amount of data for all tempers, at room temperatures and elevated temperatures in some cases, we can just about predict forming limits, or at least fracture limits.

Current design trends in materials and proportions cause production complications since the part depends highly on fabrication techniques used to make it. Residual stress pattern as well as physical properties depends on the methods used. Residual stress may affect fatigue and have a pronounced effect on warpage if any material is removed by subsequent drilling, machining, or scarging that will disturb the residual stress system. This is illustrated in Fig. 3.

Example of warpage in a rolled shape that was too large to stretch straighten is shown in Fig. 4. Warpage in this case was 8 in. in 28 ft. This particular spar required a straightening operation after every machining setup. Straightening hinders production. Each straightening operation imparts a new residual stress system so that you are never through. It requires much skill and causes considerable breakage loss.

Milled spar caps, missile fins, and milled plate wing skins have been produced from unstretched material. But this was done by brute strength and

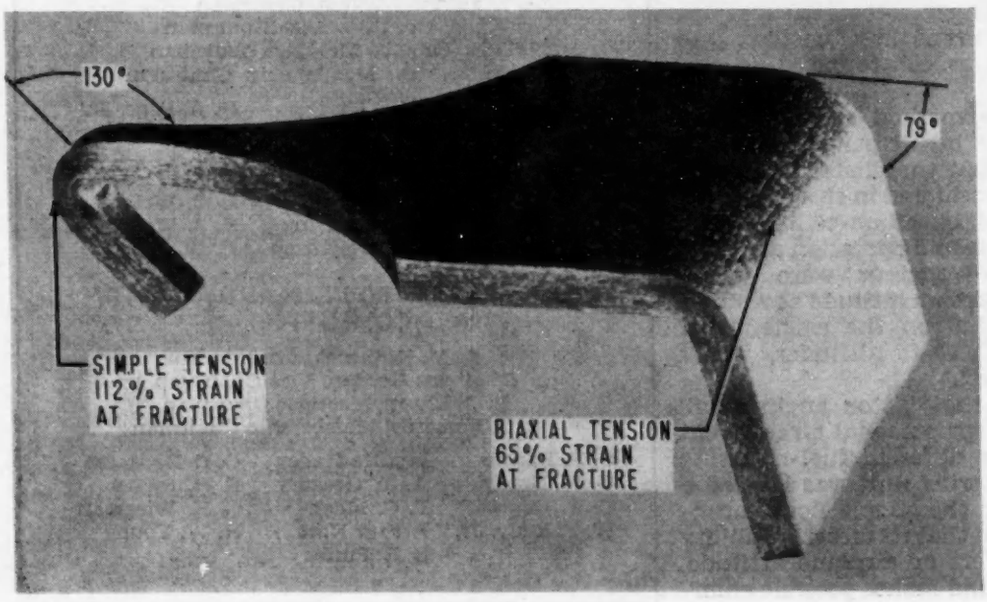

Fig. 2—This is a sample of 75SO bent to fracture. Shown here is a simple tension versus biaxial tension

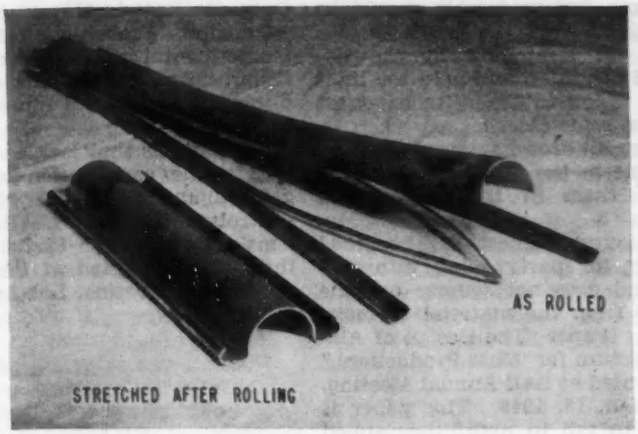

Fig. 3—Residual stresses play an important part in warpage. This is shown here. The hat section at left was stretched after rolling while the one at right was rolled in the hard condition without stretching

awkwardness that high production requirements will not tolerate.

Fortunately level stretching is an economical method of removing heat-treat distortion. But even more important, it practically eliminates high residual stress gradients both in the longitudinal and transverse directions, so that subsequent warpage from machining is nil.

Unfortunately level stretching cannot always be used because commercial equipment is limited to 750,000-lb load, or about 14 sq in. of 75SAQ extrusion. Plate capacity is 1,800,000-lb load, or 33.2 sq in. of sheet or plate limited to 7/8-in. thickness. With present-day designs predicated on milled plate, these limitations are a weak link in our national security

Effect of fabrication techniques on 75S also merits consideration. All cold

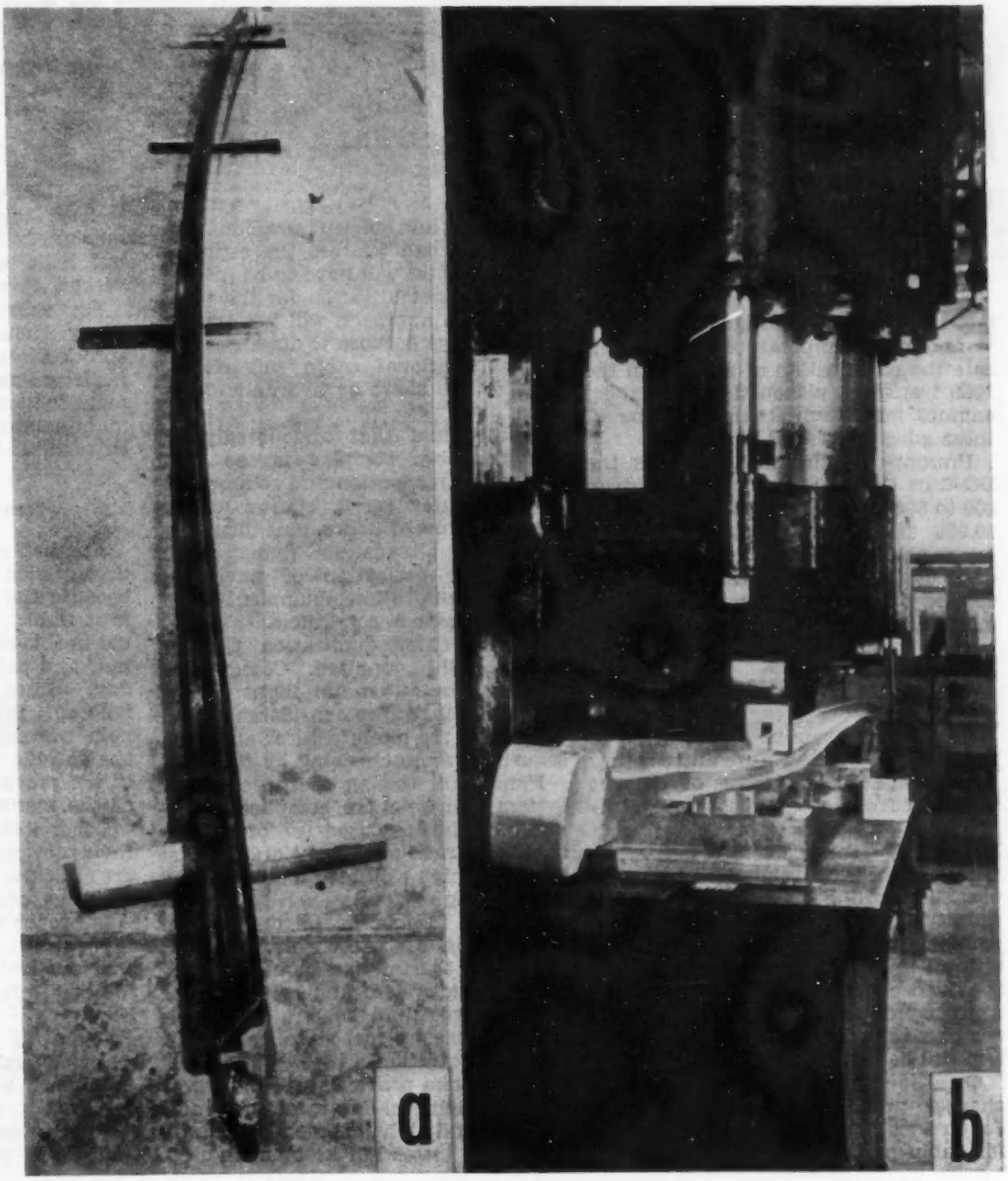

Fig. 4—The 28-ft spar in "a" was warped 8 in. by heat-treat residual stresses. It is being straightened in "b"

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work in the fully heat-treated form of this material tends to exhaust its ductility and to lower compressive properties (yield point).

Work hardening in the 75SAQ temper has the same effect to a lesser degree; but in addition, it can lower the tensile properties if interrupted aging is used. Critical amounts of strain hardening can cause excessive grain growth when combined with long soaking times in air furnaces.

All these considerations give rise to this philosophy on 75S that is extremely conservative, but worthwhile:

1. Form all 75S in the annealed condition wherever possible. (Heat-treatment distortion is the limiting condition.)
2. Form all bare 75ST hot.
3. Clad 75ST material may be formed cold to extremely generous proportions, but preferably should be done hot.
4. Do all stretching in the as-quenched condition and hold the limit of strain to low values. (Reheat-treat and age in some cases.)
5. Form all drop hammer and draw press parts in the annealed condition and size them in the as-quenched condition.

This insures highest mechanical properties for parts going into airplanes and does not squeeze out the last drop from the material to make the part. (Paper "The Design of Aircraft Structure for 'Mass Production'," was presented at SAE Annual Meeting, Detroit, Jan. 13, 1949. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Crystal Gazing on CAA OK For Jet Transport of 1955

Based on paper by

R. L. THOREN

Lockheed Aircraft Corp.

GREATER speeds, higher altitudes, and lower temperatures will complicate the certification of systems in the 1955 transport, although advent of jet engines may counterbalance some of these adverse effects.

Present-day airplanes, such as the DC-6 or Constellation, cruise between 200 to 300 mph at altitudes of 10,000 to 20,000 ft. The 1955 transport will cruise at 400 to 500 mph at an altitude of 35,000 to 40,000 ft. Altitude effect can be broken down further into atmospheric and temperature influences.

Plane Systems Compared

Now let us examine the systems of this airplane of the future and see how they compare with those of current airliners from a certification standpoint.

If the '55 transport is a turboprop type, certification related to propeller operation will be a tougher problem than at present. Combining a conventional propeller with a jet engine is still an unsolved problem. And there is evidence that the control system for a turboprop combination will be so complex that an additional safety system will be required.

On the other hand cabin supercharger problems will be simplified. Jet engines can be used as an air source for cabin pressurization. The jet engine is a big and efficient air pump. The jet engine can tolerate the estimated 1% of air that will have to be diverted to supply pressurization for the transport. This approach will net tremendous savings because it dispenses with the conventional cabin supercharger unit of the shaft or hydraulic-driven type.

One system that undoubtedly will become more complex is the radio system for navigation and communication. Greater speed, shorter endurance in terms of hours, plus increasing drive for all-weather flying makes mandatory perfection of navigation and communication equipment under adverse weather conditions.

Even greater duplication than at present will be required. Common use of radar in automatic flight control systems will require considerably more testing by the manufacturer and, consequently, more checking by the CAA.

Functional testing of the electrical system will be more complicated because of the increased use of complicated electrical equipment and adverse effects of high altitude on arcing. But the heating system may help balance the books. Using jet engine heat of compression and augmenting it with heat from the tailpipe should simplify the heating system and eliminate the need for gas-fired heaters with their usual troubles of fuel leaks, backfiring, and fire protection.

Fuel system problems will be aggravated by high fuel flow rates, high rates of climb, and high altitude, particularly if gasoline instead of kerosene is used. Only one item in this area favors the jet engine. Probably it will not be as tempermental as the carburetor of reciprocating engines about the condition of the fuel as it enters the distribution system.

Other items that look as if they will face tougher certification tests are oxygen equipment, the deicer system, flight controls, and dive flaps. (Paper "Problems of Certification-System Functioning," was presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 9, 1948.)

Preventive Maintenance Lax for Road Machinery

Based on paper by

J. W. SYMONDS

Peter Kiewet Sons Co.

CONSTRUCTION equipment makers have told users how to put their machinery together after it falls apart, but little about how to keep it together.

For example, many tractors break down from failure to adjust drive sprocket bearings. Manufacturers neglected mentioning this vital adjustment to users. But planned preventive maintenance has practically eliminated this cancer-like failure.

Practical Instructions Urged

Another case in point is the final drive pinion and bevel gear that failed because the pinion shaft nut was not kept tight. The manufacturer's manual in this case advised that every bolt, nut, and cap screw be tightened every day. Since this is impossible, it is ignored. But the manufacturer could help prevent such failures by listing the specific operation with a schedule in his preventive maintenance section of the manual.

Other items users should include in their preventive maintenance programs are clutches, cooling systems, air cleaners, tires, cables, and belts.

Improper adjustment of a clutch or failure to adjust when necessary shortens its life. When a clutch starts to slip, it is on its way to the scrap heap.

Operating with coolant low cracks many cylinder heads. Construction equipment working up and down hill alternately dries and floods heads, leading to certain failure. Proper attention to coolant level and cooling

system condition almost eliminates cracked heads.

Inadequate air cleaner service also has destroyed many engines. They must be serviced as often as every 4 hr under extremely dusty conditions. Thickening oil in the cup indicates need for service. Not cleaning the center pipe or screens also leads to common air cleaner troubles.

Improper inflation heads the list of common tire abuses. Running construction equipment with over or under-inflated tires shortens tire life. Another serious fault in tire care is failure to keep the valve cap intact.

Construction equipment tires usually need servicing twice a week. It's best to check them in the cool of the morning. Tires never should be bled when operating conditions increase pressure.

About 85% of electrical maintenance troubles and expense stem directly from low batteries or loose connections. Both reduce voltage delivered to electrical units. Low voltage forces an increase in current, which burns out the units. Periodic check of batteries and connections would prevent this trouble.

Cable Installation Tips

Another fact users should heed is that installing cable clamps with the saddle part of the clamp on the load line develops top strength. They should advance the cable periodically to remove frayed ends and reeve it right for best performance. Since most sheaves on construction equipment are undersized, attention to rope specifications takes on added importance.

Lagging or structural members rubbing against conveyor belting is another common trouble source. Adequate guards must be provided for both safety and to keep flying rocks and stones from cutting or turning over belts.

These every-day problems facing construction machinery users point to the need for an SAE committee to standardize maintenance. (Paper "The User's Viewpoint on Construction Equipment," was presented at SAE Central Illinois Section, Peoria, Nov. 15, 1948. This paper is available in full in mimeographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Temperature Rise Plotted Versus F/A

Based on paper by

PROF. NEWMAN A. HALL
University of Minnesota

AND

RICHARD C. MULREADY
United Aircraft Corp.

A SERIES of charts has been drawn, correlating ideal temperature rise with fuel-air ratio for hydrocarbon fuels to simplify performance evaluation and preliminary design studies of constant-pressure-combustion powerplants.

The series includes two basic charts of combustion chamber temperature rise versus fuel-air ratio with inlet temperature and inlet pressure as parameters, and various correction-factor charts. Corrections are plotted for variations in heat of combustion from the 19,000 Btu per lb taken as standard, variation in hydrogen-carbon ratio from the 0.182 taken as standard, lean-mixture afterburning, rich-mixture afterburning, and moisture.

One basic chart ignores dissociation effects. The correction for hydrogen-carbon mass ratio is applied to this chart. The other corrections are applied to the second basic chart, Fig. 1, which takes account of dissociation of water vapor into hydrogen and oxygen and into hydrogen and hydroxyl.

Each correction factor is valid when applied independently to a basic chart. Cumulative application gives results sufficiently accurate for engineering practice.

These charts cover fuel-air ratios from 0 to 0.12. They extend the results previously reported for lean mixtures.[1]

The charts were developed from straightforward chemical and thermodynamic analysis of the combustion process. Combustion was assumed to occur under these conditions:

1. One-dimensional steady flow.
2. Fuel injection at 77F for the heat of combustion.
3. Immediate procedure of combustion to chemical equilibrium.

(Paper "Ideal Temperature Rise from Constant Pressure Combustion of Hydrocarbon Fuels" was presented at SAE National Aeronautic Meeting, April 14, 1948.)

[1] See SAE Journal, Vol. 54, No. 12, December, 1946, pp. 32-36: "Fuel-Air Ratios for Constant Pressure Combustion," by N. A. Hall.

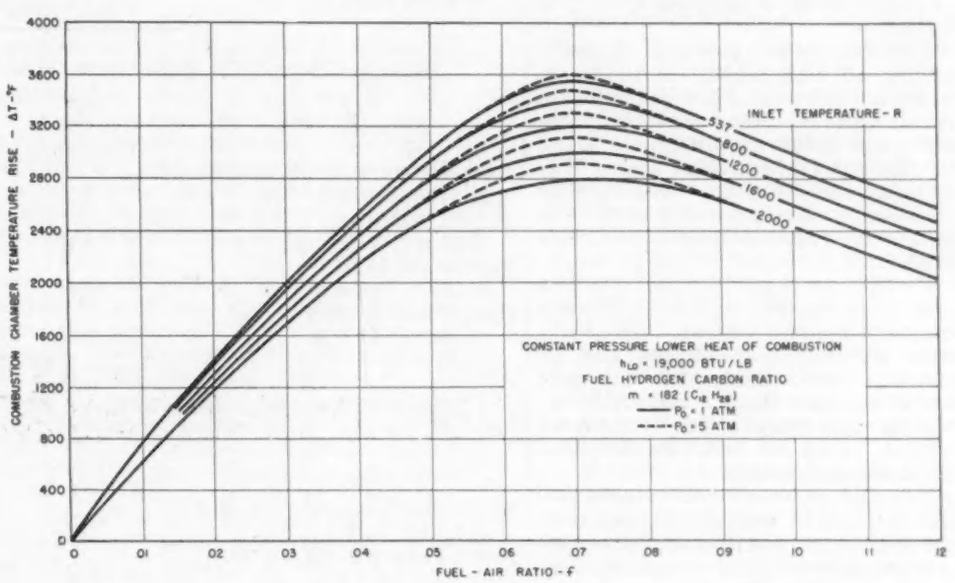

Fig. 1—Temperature rise for constant pressure combustion of hydrocarbon fuels, with dissociation

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How Oil Properties Affect Consumption

Based on paper by

CARL W. GEORGI

Quaker State Oil Refining Corp.

(This paper will be printed in full in SAE Quarterly Trans-actions)

THREE important physical properties influencing consumption tendencies of motor oils are volatility, viscosity, and viscosity index, laboratory and road test show. Oils with low volatility within definite limits, high viscosity, and high viscosity index tend to have lowest consumption characteristics.

Table 1 summarizes road test results on effect of volatility on oil consumption. (This represents evaluation based on 300,000 miles of driving in 23 cars and trucks.) Note that the volatile SAE 10 oil had consumption ratios of 1.1 to 1.8, or 10 to 80% higher consumption than the SAE 10 reference oil.

Average ratio in all vehicles was 1.3, or 30% higher consumption. This compares with a 1.9 ratio in laboratory engine tests.

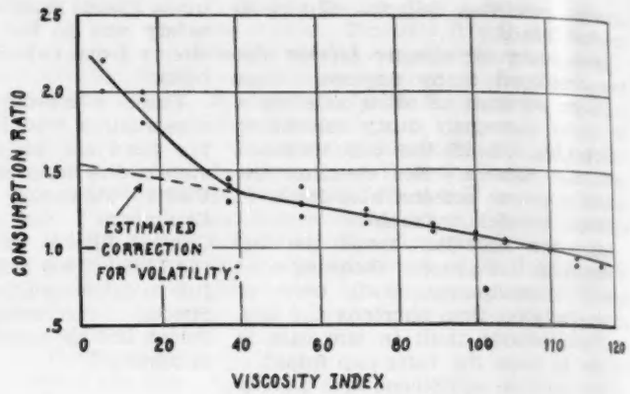

Fig. 1 — Viscosity-consumption relation obtained in laboratory engine tests. All oils are of the same type, with viscosity indexes from 105 to 115

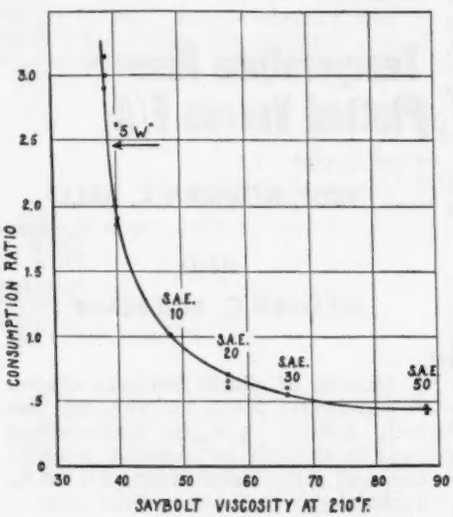

Fig. 2—Laboratory tests yielded this relationship between viscosity index and oil consumption. All oils have a 48 SUS viscosity at 210F

Volatility Effects Uncertain

Wide variation in road test results indicates the importance of adequate road data in evaluating consumption characteristics. Based on single tests, a researcher could conclude that oil volatility either makes little difference in consumption, or produces a two-fold difference.

How the second property, viscosity, affects oil consumption is shown in Table 2. These road test results again reveal quite a spread between maximum and minimum differences found in different vehicles. But average ratios decrease distinctly (meaning that consumption does also) and agree quite well with laboratory tests, summarized in Fig. 1.

Overall road test results reveal a materially sharper change in oil consumption between 5W and SAE 10 oils than between SAE 10, 20, and 30 grades. This confirms lab test data which indicate that oil viscosities below the SAE 10 range are in the most critical range of the viscosity-consumption relationship.

Effect of viscosity index on consumption is shown in Table 3. Although only one low V.I. oil was road tested, results indicate definitely higher consumption tendency for the low V.I. oil compared to the 110 V.I. reference oil.

Table 1—Effect of Oil Volatility on Oil Consumption in Road Tests

	Consumption Ratio		
	Minimum Difference	Maximum Difference	Average Difference
SAE Reference Oil, 48 SUS at 210F, 110 V.I.	1.0	1.0	1.0
SAE 10 "Volatile" Oil, 48 SUS at 210F, 115 V.I.	1.1	1.8	1.3

Table 2—Effect of Oil Viscosity on Oil Consumption in Road Tests

	Consumption Ratio		
	Minimum Difference	Maximum Difference	Average Difference
SAE 10 Reference Oil, 48 SUS at 210F, 110 V.I.	1.0	1.0	1.0
5W Oil, 40 SUS 210F, 116 V.I.	1.15	2.0	1.45
SAE 20 Oil, 57 SUS at 210F, 108 V.I.	0.9	0.45	0.7
SAE 30 Oil, 66 SUS at 210F, 108 V.I.	0.8	0.3	0.6

Table 3—Effect of Viscosity Index on Oil Consumption in Road Tests

	Consumption Ratio		
	Minimum Difference	Maximum Difference	Average Difference
SAE 10 Reference Oil, 48 SUS at 210F, 110 V.I.	1.0	1.0	1.0
SAE 10 Low V.I. Oil, 48 SUS at 210F, 16 V.I.	1.2	1.9	1.4

Table 4—Effect of Viscosity Index Improvers on Oil Consumption in Road Tests

	Consumption Ratio		
	Minimum Difference	Maximum Difference	Average Difference
SAE 10 Reference Oil, 48 SUS at 210F, 110 V.I.	1.0	1.0	1.0
Reference Oil plus V.I. Improver, 57 SUS at 210F, 132 V.I.	0.9	1.1	1.0
Reference Oil plus Bright Stock, 57 SUS at 210F, 108 V.I.	0.9	0.45	0.7
5W Oil, 40 SUS at 210F, 116 V.I.	1.15	2.0	1.45
5W Oil plus V.I. Improver, 48 SUS at 210F, 155 V.I.	1.1	2.1	1.4
5W Oil plus Bright Stock, 48 SUS at 210F, 115 V.I.	1.1	1.8	1.3

Maximum differences on the road agree quite well with lab engine values in Fig. 2; but the average road ratio of 1.4 is much less than the 1.9 lab test ratio.

Viscosity index improvers do not appreciably change oil consumption characteristics of the petroleum base oil. This shows up in both road tests (summarized in Table 4) and laboratory engine tests.

Bright Stocks Yield Results

Note that adding a V.I. improver to the SAE 10 reference oil to produce both a large viscosity increase at 210F and a very high V.I. made no noticeable change in consumption tendencies. Adding petroleum Bright Stock to yield the same viscosity increase at 210F, but with a much lower V.I., distinctly improved consumption on the road.

With the 5W base oil, evidently high consumption stems from the low viscosity and the volatility necessitated by low viscosity. Adding either V.I. improver or petroleum Bright Stock made little difference in consumption.

This investigation is not intended to condemn either V.I. improvers or their further development. But much more fundamental work must be done before their advantages and limitations can be adequately defined. (Paper "Motor Oil Consumption Characteristics," was presented at SAE National Fuels and Lubricants Meeting, Tulsa, Nov. 5, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Kitchen Chemistry Explains Viscosity Index Improvers

A mixture of peas and spaghetti seems to represent a reasonable analogy to a mineral oil-polymer blend and may aid in visualizing why large differences in viscosity can occur in such a blend with no physical or chemical change other than rate of flow or shear.

Viscosity index improvers are complex polymers of very high molecular weight, characterized by a long, straight chain structure with short side groups. A polymer-mineral oil blend may thus be likened to a handful of spaghetti mixed into a cup of peas, the spaghetti representing the polymer molecules and the peas the oil molecules.

At very low rates of flow, such as pouring the mixture from a cup, which may be considered the equivalent of low rates of shear, the sphagetti is heterogeneously mixed with the peas and forms a criss-cross matrix to impede flow of the peas. This hinderance of flow is equivalent to an apparent increase in viscosity.

At very high rates of flow, such as forcing the sphagetti-pea mixture through a pipe at high velocity, which corresponds to high rates of shear, the strings of sphagetti will tend to become oriented parallel with the direction of flow. Thus they will offer less impedance to flow of the peas. This greater flowability is then the equal of an apparent decrease in viscosity, although the mixture is not altered as to composition or temperature, and the only change being that of rate of motion.

Airlines Able To Make Profits

Excerpts of paper by

H. D. KOONTZ

Director of Commercial Sales
Consolidated Vultee Aircraft Corp.

GIVEN a sensible route, realistic management, adequate modern equipment, sound Government regulation, an adequate method of financing, I believe the airline business can hold its own with American industry.

Reasons why this industry is losing tremendous sums in a period of high prosperity have been inadequate financing, managerial errors, lack of sound Government policy, and the natural inefficiencies in expanding operation 1000% in four years.

Tremendous strides have been made in one short year in reducing airline costs toward the goal of breakeven load factors to a level of 50% for passenger load, and 45% for payload factor. This may never be accomplished, but the industry is headed in the right direction.

The airline industry has reduced costs in face of a 100% rise in business costs since 1938 to an astonishing degree.

In 1939 total cost per available seat mile for domestic carriers was 4.2¢. This rose to 5.1¢ in 1943, dropped to 4¢ in the second quarter of 1948, and now must be well below this figure.

One of our largest carriers now in process of completely modernizing its fleet showed 4.3¢ cost per available seat mile in 1939 and reported a cost of 3.6¢ in the third quarter of 1948. When in full operation, this should be considerably lower. Not many industries can boast such performance.

Most of this decade's improvement in costs occurred since the beginning of 1947 and is coincident with the revised program of cost control and use of more efficient equipment.

Breakeven load factors have been considerable. In 1946 all domestic carriers required a passenger load factor of 80% to break even, but in the second quarter of 1948 only 61% was necessary. A major carrier may show a breakeven factor of 50% during 1949, although its factor was 83% in 1946.

With all realism possible manufacturers, investors, airline managements and personnel, and the Government must pursue relentlessly solutions to these problems resulting from the complexities of this business:

● Safety regulations appear unreasonable. Fire and smoke warning devices cause far greater hazards than the almost non-existent hazards they are designed to protect against. A short circuited "No Smoking" sign burned out the interior furnishings

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and endangered the passengers, yet cigarettes have not been proved a hazard.

● Gasoline reserves continue to be based on time and distance factors of the slow Ford Tri-Motor or DC-2, thus displacing hundreds of revenue payload pounds.

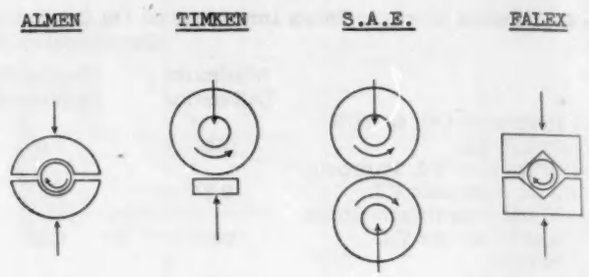
● Potential passenger traffic is kept from airlines because schedules are unreliable and many are still afraid to fly. Good service generates traffic.

This industry has only begun to tap the volume market of the railroad coach passenger business.

Railroad and bus line experience would cast doubt upon the ability of an airline to give service and operate with an average passenger load factor of more than 50 or 55% over an extended period. To better this, a domestic airline would be extremely fortunate in having an unusually favorable traffic pattern, or would not be giving adequate service.

The Civil Aeronautics Board, with its airport program, its policy of simplifying regulations, its attitude toward new routes and mail pay, and its willingness to permit experimentation in this young industry, seems to be headed in the right direction.

The pendulum has swung from wild optimism of four years ago to unreal pessimism. No one should overlook the vitality which exists and has existed in the business of air transportation. All should take hope from the progress which has been made, even during the past three years of losses. (Paper "Must Airlines Lose Money?" was presented at the SAE Southern California Section, Feb. 10, 1949. This paper is available in full from the SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)



	ALMEN	TIMKEN	S.A.E.	FALEX
	1/4" pin	1 7/8" cups		1/4" pin
Shaft Speed rpm	600	800	1000	300
Rubbing ratio	39.3 ft./min	400 ft./min.	14.6:1	19.6 ft./min.

Fig. 1—Gear lubricant test machines

Gear Lube Testing Procedures Compared

Based on paper by

W. B. BASSETT

The Lubrizol Corp.

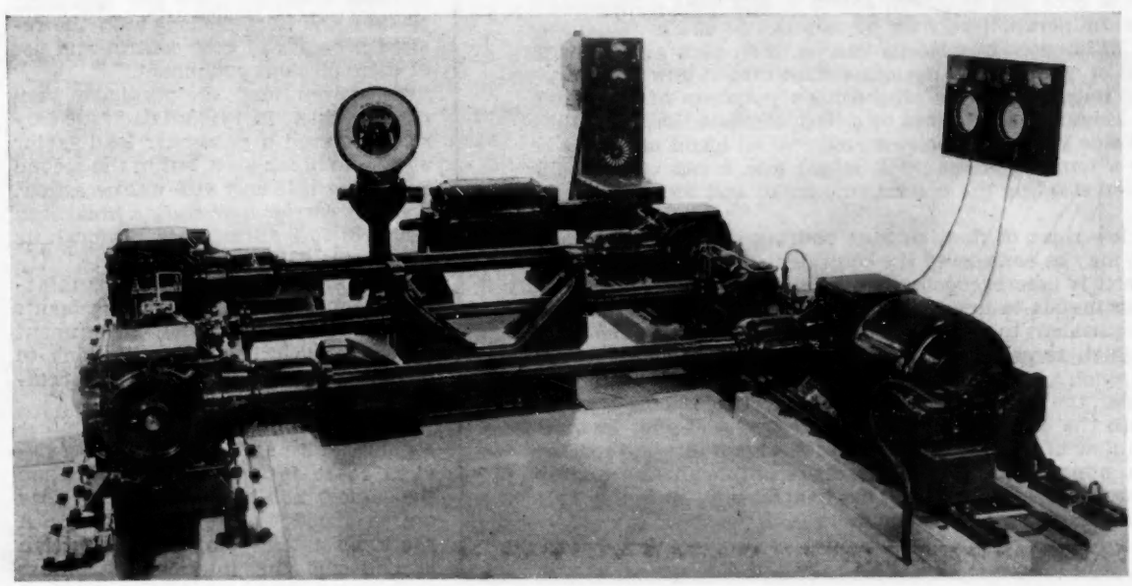
FULL-SCALE axle tests evaluate gear lube characteristics better than laboratory bench tests formerly used. But much remains to be done in developing laboratory tests that predict service performance of gear lubricants.

Laboratory bench test machines used in earlier work with gear lubricants are shown in Fig. 1.

The Almen and Falex machines are quite similar, using a ¼-in. hardened steel pin as the rotating test specimen. In the Almen design two circular blocks apply pressure on the pin, while V-shaped blocks are used in the Falex. Developers of the Falex machine believed the V-shaped blocks would eliminate effect of viscosity, giving a more accurate measure of film strength.

In the Timken machine a 1⅞-in. roller bearing cup is rotated against a

Fig. 2—This four-square machine is one way of evaluating gear lubricants in high-torque low-speed operation. One of the two full-scale axles is under test while the other completes the power transfer circuit



fixed steel block through which the load is applied. The SAE machine is similar to the Timken in that two of the same roller bearing cups are used. These are mounted on separate shafts that are normally geared to produce a rubbing ratio of 14.6 to 1. Changing the gears will vary the ratio.

The SAE, Timken, and Falex machines produce a line contact which should minimize the effect of viscosity, but prevents loss of line contact from wear.

In testing lubricants all these machines indicate that rapid wear or actual deformation of bearing surfaces does not occur until a certain load has been exceeded. But experience has shown that results from these machines are not reliable criteria of hypoid-gear lubricant performance.

Axle Tests Better

It is agreed that film strength and stability tests using full-scale axles yield better results. Such full-scale axle performance tests are required by U. S. Army Specification 2-105B for gear lubricants.

For example, one of the test setups used for evaluating high-torque low-speed operation, called for in 2-105B, is known as the four-square machine, shown in Fig. 2.

Here two full-scale rear-axle assemblies are used; one is under test while the other completes the power transfer circuit. Load is applied by winding up the system through one of the corner gear boxes until desired torque is reached. An electric motor geared to one of the shafts furnishes the rotation.

Fig. 3 shows the type of results obtained in the high torque test.

Service and Lab Tests Compared

Service field tests are another way of evaluating performance of automotive gear lubricants. But results of service tests have not been too reproducible.

Our laboratory and apparently several others have experienced differences between laboratory and service results. For this reason we are trying to develop a laboratory procedure that correlates better with service. Most of this work involves a 1½-ton axle using conditions comparable to full throttle in first and second gear.

This means of predicting service performance shows considerable promise. (Paper "Performance Characteristics of Automotive Gear Lubricants," was presented at SAE National West Coast Meeting, San Francisco, Aug. 20, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

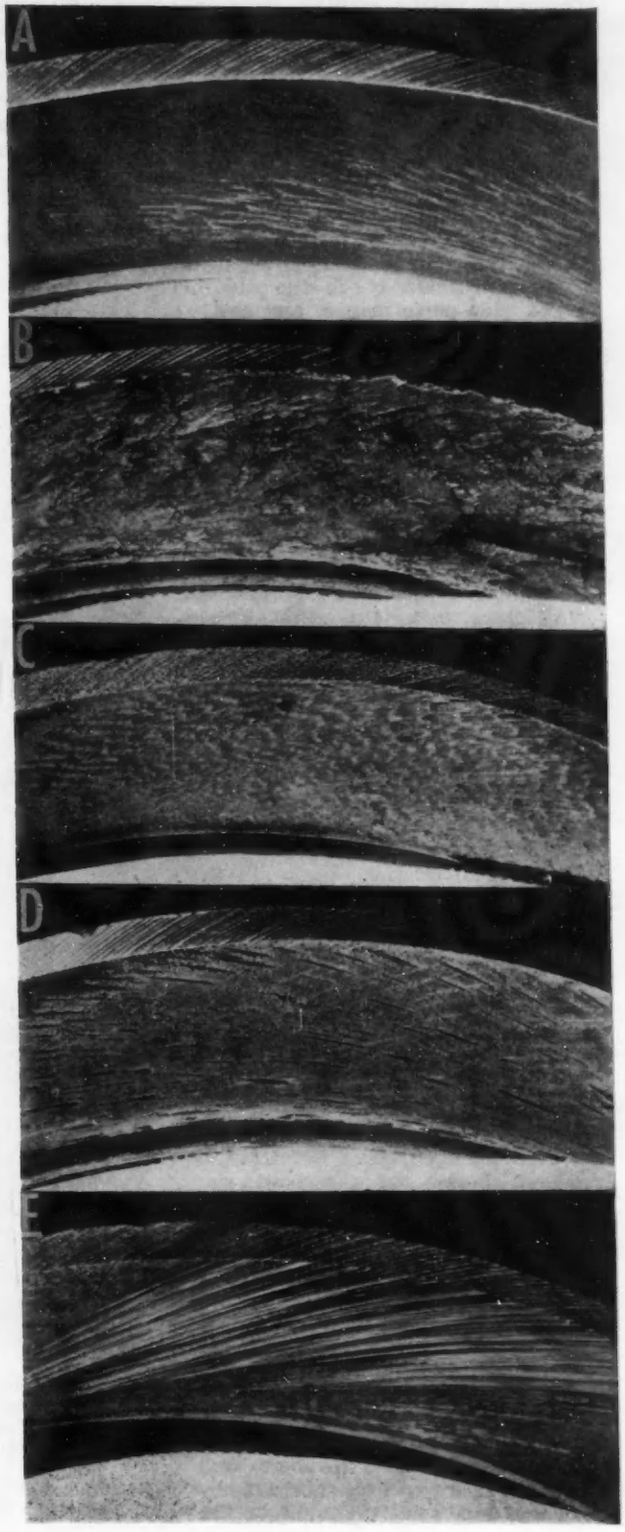


Fig. 3—This series of photos illustrates the results of a high-torque test. "A" shows the drive side of a new pinion tooth with its original surface finish. After running for 3 min on straight mineral oil after load application, it took on the appearance in "B." Note the places where welding action took place. Another type of failure, shown in "C," is described as a rippled surface; that in "D" is considered rippled. Both of these are said to stem from plastic flow of metal under the load and speed used in this particular test. The tooth in "E" is from a test on a 2-105B product and shows normal wear with no surface distress. By comparing this with the new gear in "A," you will recognize the dark irregular lines along the surface as tool marks

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Frame and Body . . .

Frame and Body Versus

Based on paper by

D. W. SHERMAN

A. O. Smith Corp.

THE frame car costs less to make and to develop than the frameless car, although it weighs a little more. A separate frame also probably costs less to repair, particularly in case of major collisions.

These comparisons are emerging from a research program started about two years ago. Its aim is first to analyze and check thoroughly the structural and cost characteristics of a production car with unitized construction; next step is to redesign and rebuild the car to take a separate frame, and again check the car for weight, ride performance, and cost.

The program has progressed to the point where rigidity checks have been completed. Much work remains to be done on cost studies. But the car with separate frame weighs 30.2 lb more than the original frameless design, while its overall rigidity is slightly less. We expect to increase the rigidity to somewhat above the production setup by stiffening the frame at the body mounting points. Overall weight should not be increased significantly.

"A" in Fig. 1 is a cross-section through the body floor and sills of the production (frameless) design, while "B" is the reworked construction including the frame. The frame cross member and body outrigger shown are located at the rear of the cowl. The body bolt anchors directly to the lower end of the pillar. Rigidity of this cross beam and its tie-in to the pillar is extremely important.

To get still greater rigidity in the combination we plan on replacing the channel with a flash-welded "I" section beam similar to the section used for some frame "X" members.

Comparing the two designs reveals that the original sill has been completely removed, while the outer trim panel has been closed with a side plate and becomes the sill in the new design.

All body bracing ahead of the dash has been removed. But by virtue of improved design of the cowl side panels, the stiffness between dash and rear axle is somewhat better for the body alone. At the same time attaching points for the frame have been provided that are greatly superior to anything yet used in separate frame and body construction.

The separate frame design removed 59 pieces weighing 139.8 lb from the body (including small gussets, spacers, and component parts of subassemblies such as the front cross members) and eliminated 1508 spot welds and 112 key welds and arc welds. Weight of the added separate frame is 170 lb, but this includes some of those parts eliminated from the body—for example, the front cross member. However, those parts now included in the frame contain less labor content than did their counterparts in the unitized design.

Fig. 2 shows up another structural advantage with the separate frame. "A" is a horizontal cross-section through the production cowl, while "B" is the reworked design. The side panels in the production design are badly curved and cannot furnish the required shear for resisting fore and aft loading. In the production car this loading is resisted by the diagonal bracing forward of the dash. In the reworked cowl, the side panels are brought to the inside of the pillars. They are flat and are placed almost parallel to the centerline of the car.

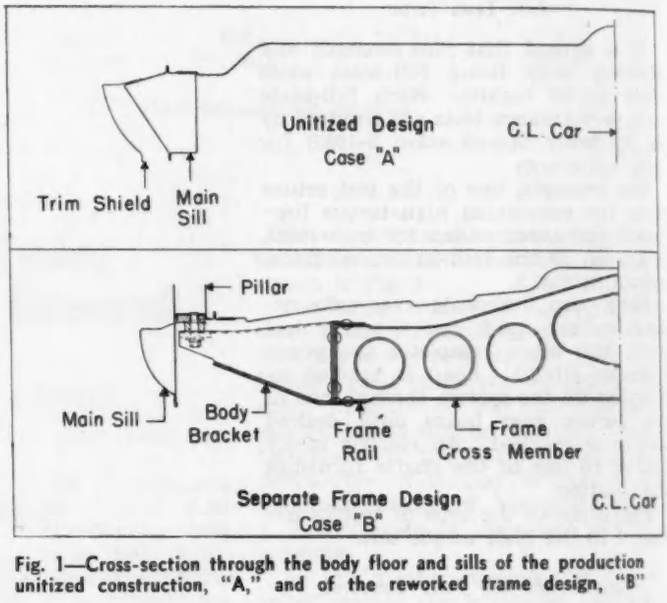

Fig. 1—Cross-section through the body floor and sills of the production unitized construction, "A," and of the reworked frame design, "B"

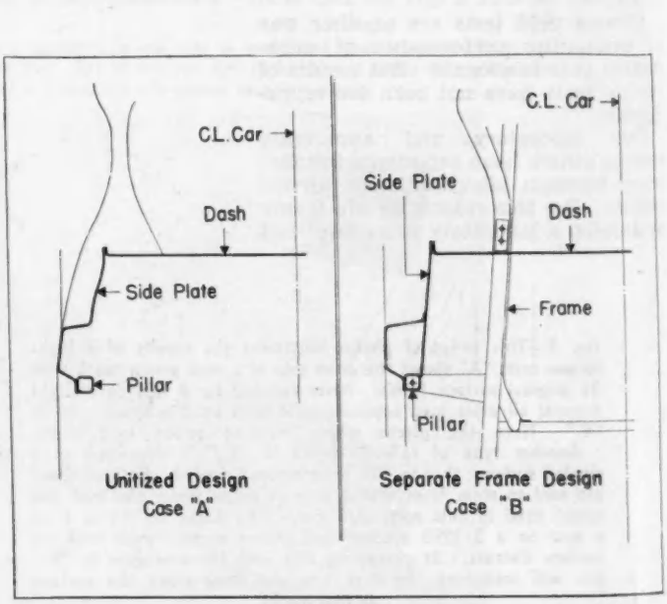

Fig. 2—Section through the cowl of the unitized design, at left, and the frame version, at right. The frame cowl was 17% stiffer in tests than the unit type

Unitized Construction

Actual tests on the two constructions show the reworked cowl to be 17% stiffer than the frameless design, although the reworked design spans a much shorter area and, therefore, theoretically carries higher moments.

In development time and expense the frame construction holds the advantage. Reason: the frameless car uses the body as a structural member which must be developed as a specialized form, requiring extensive laboratory research. Present time schedules on model changes might be seriously upset and development costs excessive if we were to do away with the frame.

Cost of repairing collision damage to a unitized car as compared to one with a separate frame cannot readily be determined. But it seems rather good business, especially in major collisions, to transmit the shock to the light-gage body through a heavier-gage medium, such as a frame. Localized deformations will be less severe.

The heavy-gage frame of relatively open section can more easily be brought back to dimension than can springy, light-gage members of closed sections. Making light-gage metal look nice is different than reworking to precise alignment. (Paper "The Frame and Body Construction," was presented at SAE National Passenger Car, Body, and Production Meeting, Detroit, March 9, 1949. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Unitized Construction . . . .

Based on paper by

A. R. LINDSAY

The Budd Co.

UNITIZED car construction reduces weight, saves heavy-gage steel, equipment, and floor space, and simplifies assembly.

These advantages show up by examining a ⅛-scale model—which does not represent an actual car—past, present, or future.

As shown in Fig. 1, the body being built and designed today for mounting on chassis frames is ideal for unitized construction. Very little, if any, change is required back of the dash and above the floor line. Part forward of the dash requires added bracing. Floor pan of the conventional body requires only slight changes for unitized types. The side sills may be constructed in many ways.

A cross member is required at the front of the front floor, to which is bolted the engine rear support. As in the case of the conventional body, the front seat must be supported by two cross members.

In the rear floor pan, mountings must be provided for the front and rear ends of the longitudinal springs. This is done by placing box section members on the bottom of the floor pan, taking advantage of the natural stiffness of the existing rear seat riser at the front, the rear cross sill at the back of the body, and the formed-up dome-like wheel housing in between.

The rear shock absorber is mounted at its upper end in a housing provided on the floor and attached to the vertical wall of the wheel housing. Depressions and small reinforcements are provided in the rear floor to carry the gas tank.

By using in this way metal already existing in the conventional body, we evolve a structure 50% stiffer tor-

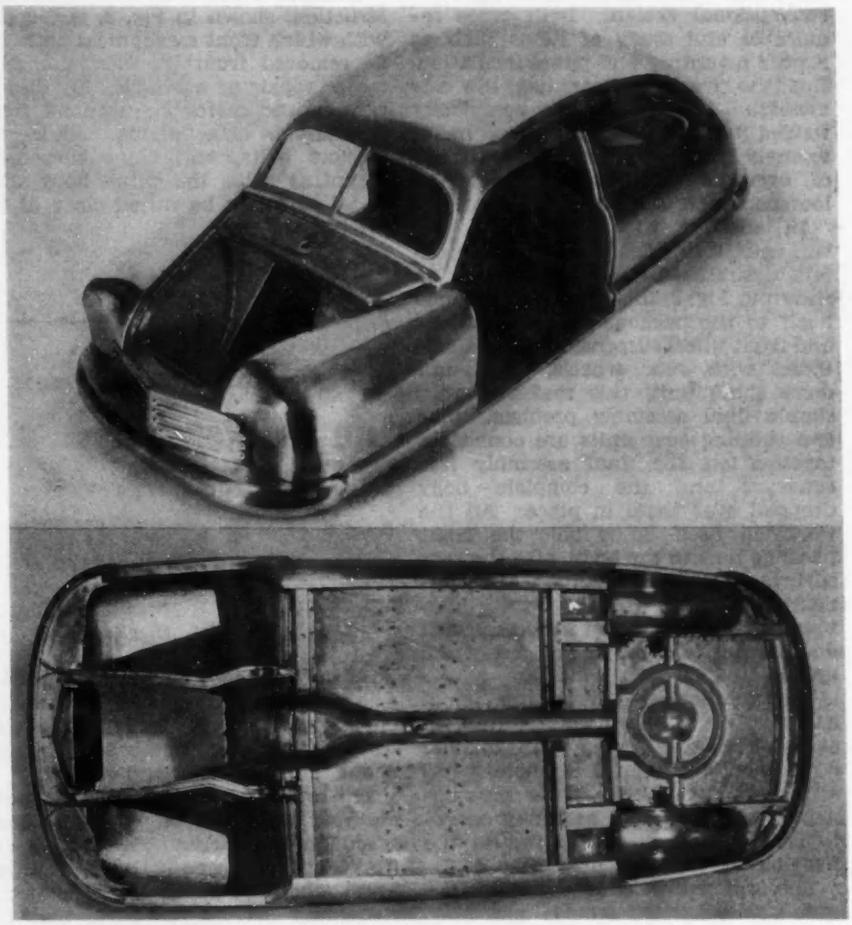

Fig. 1—Model of a unitized construction car. Note the diagonal braces which are placed between the side sill member, directly above the front wheel suspension cross member, up to the intersection of roof panel and dash. These braces fit in with, and are securely welded to, parts such as the dash, cowl side panel, and radiator core supports, forming one solid unit with the body structure.

Advantage here is that mass stiffness of the whole unit extends forward to hold securely the front wheel suspension. It stops shakes and vibrations, from road shocks, at their source

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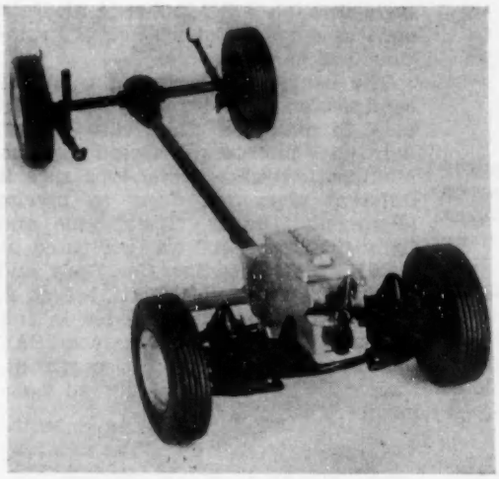


Fig. 2—Unitized construction is well-suited to assembly with a packaged powerplant combined with the running gear units and propeller shaft assembly

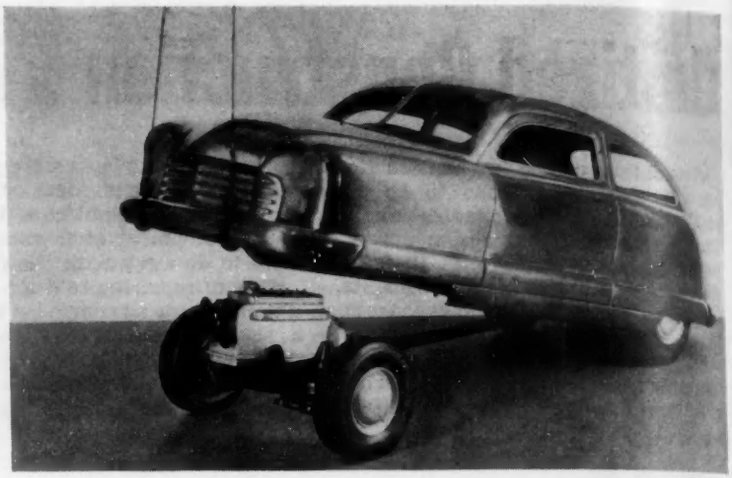


Fig. 3—The frameless body can easily be disconnected from the front mechanical units for repair work

sionally than the conventional body mounted to chassis frame.

The unitized car presents no greater noise and vibration problems than the conventional design. Both cases require careful study of items such as rubber mounting and panel insulation. But the frameless car has the advantage of being one completely welded unit with front sheet metal securely held; this lessens the chance of eventual body noises caused by loosened parts such as body bolts.

In addition to its structural advantages, the unitized construction offers desirable assembly features. As shown in Fig. 2, this construction lends itself to the package-type powerplant and front wheel suspension unit. Combined with rear wheels, axle, and drive shaft unit, this makes a very simple final assembly problem. The two running gear units are connected together on the final assembly line conveyor and the complete body dropped over these in place. All the workmen need do is bolt the front package unit to the body, also the rear springs and shock absorber, and connect the steering linkage, wiring harness, radiator hose, and so forth. Men do not have to climb in and out of the upholstered body.

This method greatly shortens final assembly lines, where workmen are in each other's way trying to make final adjustments between sheet metal parts and the body. This arrangement obviously saves in final assembly operations, which is bound to reduce the final cost.

The unitized car also eliminates the complete chassis frame assembly, which means tremendous savings of factory floor space and necessary equipment, such as batteries of heavy presses for side rails, riveting machines, conveyors, paint dip tanks, and receiving and handling of heavy steel.

The 185-lb chassis frame is replaced by about 55 lb of low-cost, light-gage steel stampings—a net saving of 130 lb in steel alone.

Another feature of this type construction, shown in Fig. 3, is the ease with which front mechanical units can be removed from the car in case of major repair or overhaul. By disconnecting the motor connections (such as radiator hose, wiring, motor rear support bolts, and front suspension mounting bolts, the entire body sheet metal unit can be raised clear of the mechanical unit.

With the conventional chassis, it is necessary to remove most of the front sheet metal, disconnect the engine completely, and take it out through the top. (Paper "The Advantages of the Unit Type Construction in Automobile Bodies," was presented at SAE National Passenger Car, Body, and Production Meeting, Detroit, March 9, 1949. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Life and Repairs Of Frameless Car

Based on paper by

THEODORE ULRICH

Nash Motors Division,
Nash-Kelvinator Corp.

THE unitized body stands up in service as well as the conventional frame and chassis car, wartime experiences with Nash cars showed, and repairs involve about the same work and cost.

The unitized Nash car, first produced one year before the war, proved a good specimen for learning about the service life of this design. During the war years, when the public did without the customary service for parts and repairs, it was possible to check periodically structures of both Nash cars and cars with separate frames. Under these conditions, the unitized body performed well.

Wartime experience did yield some pointers on improving unitized design. For example, certain areas in the underbody are road sandblasted. Protruding mechanical parts in certain locations are subject to this action. Experience also reveals that it is easier to seal a welded joint and prevent corrosion if the joints are on the top surface of the floor rather than the bottom.

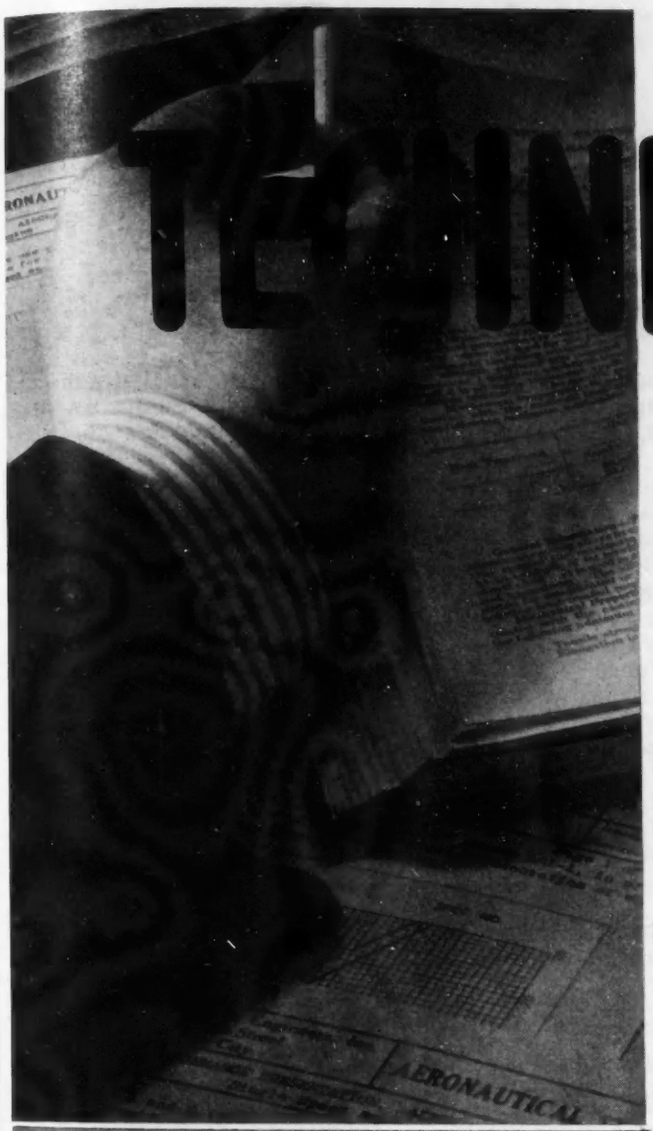
Repair problems with the unitized body and the conventional body are identical—no more difficult or costly. In either case it is necessary to straighten out the buckled panels and box sections and gas or arc-weld in service panels, solder up, and finish.

With the unitized construction, damage usually is localized at point of impact. Distortion or misalignment rarely extends throughout the structure. By removing attaching bolts it is comparatively easy to remove suspensions, engine, or axle units in case of repairing a body at these points. Where the body is damaged beyond repair, the problem is about the same as on the conventional car.

A recent survey disclosed that ex-

Cont. on p. 92

TECHNICAL COMMITTEE PROGRESS



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SAE Issues Revised Aero Spline Standard

THE recently-revised SAE Aeronautical Standard on involute splines, AS 84B, is particularly well-suited to aircraft engine use, according to the SAE Aeronautical Involute Splines Committee which prepared this standard. Released at the same time was revised Aeronautical Recommended Practice ARP 179A—Involute Spline Gages (30-deg Pressure Angle).

AS 84B—Splines, Involute (Full Fillet), specifies a full-fillet spline which minimizes stress concentrations at teeth roots. This standard provides efficient, durable, and easily-fabricated splines for aircraft engines and similar high-performance equipment.

Aircraft engine designers prefer AS 84B to the spline specified in American Standard B5.15-1946. The ASA spline has a flat bottom on the OD and ID of the splines because that is where the splines are piloted during machining. The spline in AS 84B is piloted on the side of the spline.

Chairman of the SAE Aeronautical Involute Splines Committee, G. Carvelli, Wright Aeronautical Corp., notes that weight saving is important in aircraft engines; therefore, the full-filleted AS 84B spline is preferred to the sharper radii of the ASA spline for such equipment. Automobile manufacturers, he observes, do not stress their parts as highly as aircraft engine makers. Thus ground vehicle manufacturers may find it cheaper to add weight to a part and produce a spline with sharper corners at the bottom.

Another primary difference between these two standards is the method of determining the

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Gustaf Carvelli
Wright Aeronautical Corp.

Chairman of the SAE Aeronautical Involute Splines Committee

dedendum. In AS 84B, the dedendum is a constantly increasing percentage of pitch. This constant increase is graduated to provide maximum fillet radii and to minimize the weight of the shaft.

The dedendum for the ASA standard equals 0.9/P up to, and including, 12/24 DP and 1.0/P above 12/24 DP. This difference affects other factors related to tooth contour including radius, tooth height, and weight.

Another difference is that AS 84B specifies root radius as approximate R, which actually means approximate average. The American Standard calls for a minimum radius. And the fit is a specified requirement in the American Standard; it is not in AS 84B. American Standard B1.15-1946 also specifies the allowable error in spacing while AS 84B omits this requirement.

A gaging standard—ARP 179A—supplements AS 84B and gives full gaging information for both "go" and "no go" limits. No gaging practice has yet been established for the American Standard.

Plan Bucket Spec For Earthmovers

CAPACITY and dimensional specifications of front end loaders for earthmoving equipment was undertaken as its first job by the Front End Loaders Subcommittee, of the SAE Construction and Industrial Machinery Technical Committee.

The Subcommittee, chairmanned by T. Davidson, Bucyrus-Erie Co., currently intends to consider only two types of buckets—gravity dump and controlled dump.

The group is considering methods to measure "struck" and "heaped" bucket capacity. Dimensional specifications being studied include clearance height under bucket in carrying position; height under bucket when dumping; and clearance height above bucket to permit dumping.

Aero Committee Hydraulic

A recent week-long meeting at Dayton coordinated the work of three committees on aeronautical hydraulic and pneumatic equipment, of the SAE Aeronautical Committee. Industry and government specialists pooled their knowledge to solve both civil and military problems in this area.

The three groups were: SAE Committee A-6, Aircraft Hydraulic and Pneumatic Equipment, SAE Committee A-1, Aircraft Pumps, and SAE Committee A-3, Aircraft Valves, Fittings, and Flexible Hose Assemblies.

Typical of the problems discussed and acted upon is the question of plastic versus metal closures for hydraulic equipment. (These closures, covered by Specification AN-C-150, are threaded caps placed in openings of hydraulic units to keep out dirt before installation.) Previously industry objected to wood or plastic closures due to possible shredding or chipping, and recommended that only metal closures be permitted by specifications.

Recent experience shows that present plastics—such as the acetate type of thermal plastic—should not chip or shred. Both industry and the military services now accept the plastic closure, discussion at the meeting disclosed. So, revision of AN-C-150 was recommended to permit use of both plastic and metal closures. SAE Committee A-3 has been asked to prepare a revised draft of the specification, coordinate it with industry and interested military personnel, and then forward the results to the Aircraft Industries Association for transmittal to the Aeronautical Standards Group (representing the military).

Other projects acted upon by these Committees individually at the meeting are reported below.

SAE Committee A-6 Aircraft Hydraulic and Pneumatic Equipment

B. R. Teree,
New York Air Brake Co.

ITEMS ranging from generalities, such as the future of pneumatic systems, to specifics, such as flareless tubing, occupied SAE Committee A-6 during its three-day meeting.

Most airframe manufacturers' engineers felt that in no case can pneumatics completely replace the hydraulic system. Hydraulic systems are still required for power boost controls.

But most engineers were interested in pneumatic systems. Some said they are continuing studies of them. One engineer reported his company found insufficient benefits in weight and performance to justify use of pneumatic systems. Another suggested that the hydraulic power boost system be separated from the remainder of the power systems, and that air should be used in all other systems, particularly for landing gears and flap operation.

Lack of an adequate compressor system was noted as the most critical problem. The Committee suggested that the Air Materiel Command's Powerplant Laboratory give priority to development of a satisfactory compressor.

While hydraulic control systems apparently will predominate for a long time, it appears that procedures for testing hydraulic equipment still pose problems for suppliers and buyers. Committee members and guests said differences in test methods and procedures from one laboratory to another produced discrepancies.

For example, Air Materiel Command

Groups Ponder Equipment Problems

test results in many cases differ widely from results of manufacturers' tests. Airplane manufacturers also find differences when the same individuals in the same laboratory of one company test two items of the same design. The Committee sees no immediate solution to the problem, but feels it merits further discussion.

The Committee moved from lab tests to tests in the field to uncover a basis for brake system design. It heard reports from the Pacific Division, Bendix Aviation Corp. and Vickers Inc., which are conducting such studies. Preliminary reports noted that the Air Force brake system test program does not indicate a definite basis for design of brake systems. However, it has shown that pilots can satisfactorily operate an airplane with big differences in brake control. Apparently a pilot will learn to like any brake system that stops an airplane, regardless of the lack of pedal load.

One aid to designers of brake as well as complete hydraulic systems being developed by the Committee is a hydraulic system nomenclature. This nomenclature, being prepared as an SAE Aeronautical Recommended Practice, is near completion.

One change in hydraulic systems that industry favors is the switch from flared to flareless tubing. Engineers reported that the flareless type fitting is superior to the present AN type fitting, according to tests and service experience. Standardization of tube fittings currently is being investigated by the National Aircraft Standards Committee.

SAE Committee A-3 Aircraft Valves, Fittings, and Flexible Hose Assemblies

L. J. Henderson, Aeroquip Corp.

SEARCH for better powerplant flange fittings for fuel and oil lines directed SAE Committee A-3 discussions to merits of a flat gasket versus O-rings as seals.

Engine manufacturers prefer the O-ring for flange fittings. But engineers from accessory and airplane manufacturers and the military services at the meeting felt that experience over the past few years shows the flat gasket seal preferable to O-rings. A satisfactory O-ring seal design is not anticipated by some engineers for powerplant flange fittings.

A design suitable for both O-ring and flat gasket seals was not considered feasible because of weight and size penalities.

But from this discussion emerged the recommendation that the flange boss might be machined flat suitable for a flat gasket, and that two different type flanges might be developed for use on this surface—one of these designed for a flat gasket, the other for an O-ring seal.

The Committee also furnished the military services with data on bend radii for hose meeting specification AN-H-24. The radii shown in charts of Fig. 1 were recommended for such hose assemblies. The committee suggested that an AND design drawing be made to show the bend radii for all hose assemblies. This would obviate changing specification AN-H-2 and various hose specifications whenever a minor change is made in bend radius.

SAE Committee A-1 Aircraft Pumps

J. M. Kidd, Glenn L. Martin Co.

OVER 30 members and guests of SAE Committee A-1 focused on pump operating problems, with particular attention given to high altitude, extreme low temperature operation and to pressure peaks.

Low air temperatures and pressures at high altitudes were said to foreshadow more critical pump requirements in the future, especially the need for pressurization of the reservoir at high altitudes.

The pump will have to operate continuously under stabilized conditions at temperatures below -20F. In fact, temperatures as low as -65F now are being considered as a requirement.

Compliance with such additional requirements were labeled a must if hydraulic systems are to remain.

High inlet pressures of about 100 psi were mentioned as another probable requirement in new hydraulic pump designs. One danger seen with such requirement is the complete loss of the hydraulic system in case of loss of pump inlet supercharge pressure.

Two alternatives were seen as to pump inlet pressures: (1) specify that the pump shall operate at high inlet pressure, or (2) make the airplane manufacturer responsible for designing a pressurizing system so that the pump will operate at all altitudes.

The question of specifying maximum pressure peaks for pumps elicited varied comments.

It was pointed out that including a requirement on maximum permissible pressure peak from the pump is valuable to airplane manufacturers in designing hydraulic systems. Specifying such a pump test in detail makes it reproducible in different laboratories.

However, it was generally agreed that a requirement on rate of pressure rise should not be included in pump specifications at this time.

Stringent pump operating conditions steered discussion toward need for development of an engine-driven hydraulic pump, suitable for operation at relatively high speed. Such a

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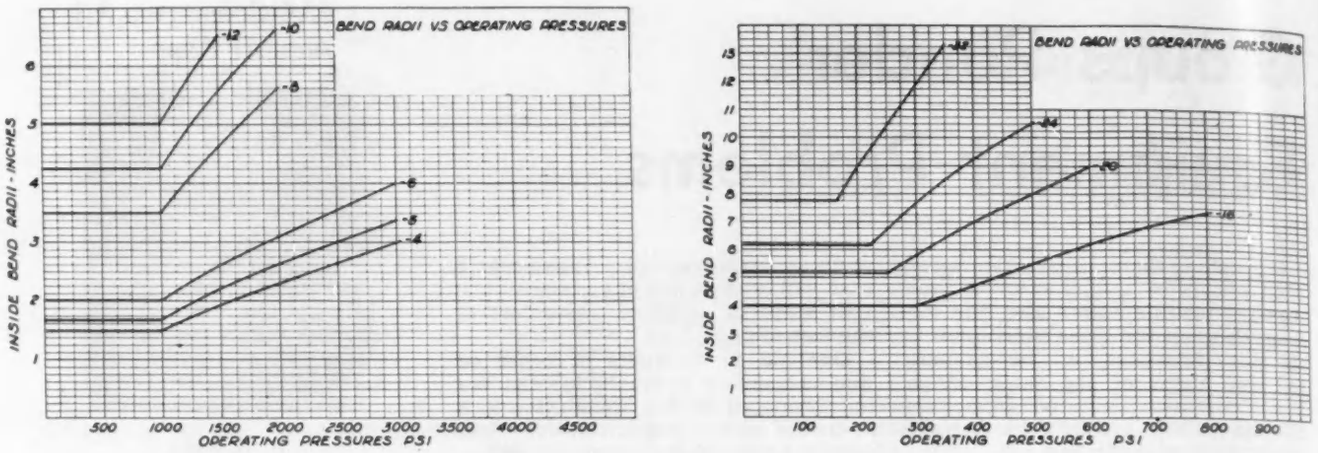

Fig. 1—Bend radii recommended by SAE Committee A-3 for hose to specification AN-H-24

pump, it was felt, should be suitable for use on the generator or alternator engine drive pads.

It was reported that a pump of this type to deliver 25 gpm at 3000 psi and 8250 rpm, is under development. It will work with either an open or closed hydraulic system. But big need for such high-speed pumps is predicated on possible future change to closed circuit systems.

The Committee agreed to prepare recommendations, if necessary, for possible revisions of AN-P-11b to cover such high-speed pumps.

New Threads Need User Cooperation

ASA Sectional Committee on Standardization and Unification of Screw Threads, B1, co-sponsored by SAE and ASME, recently issued the following release to industry to help ease the switch from the 1935 screw thread standards to the new Class 2A and 2B tolerances:

"The most significant modification in the Unified and American Screw Thread Standard is the addition of classes 2A and 2B.

"Class 2A is an external thread classification which provides an allowance or clearance between its maximum metal condition and the minimum metal condition of any class of internal thread into which it assembles. This clearance minimizes galling and seizing in high-cycle wrenching and high-temperature applications. It also accommodates plating when required.

"Class 2A is recognized as standard practice for production of screws, bolts, and other threaded fasteners. Class 2B is the realistic approach to the tolerances required in the production of standard nuts.

"Changing to Classes 2A and 2B does not affect strength or interchangeability. Components are mechanically and functionally interchangeable in any combinations of the old and new Classes.

"Specification and adoption of these new Classes of threads into actual practice will require restraint on the part of the users to afford manufacturers opportunity for reduction of present inventories of finished product and the working off of current stocks of tools and raw materials.

"To implement changeover to the new Classes of threads, users for an indeterminate period should specify the new Classes as optional. Conversely when specifications are not changed, users should accept the new Classes as optional.

"Producers and users have agreed that implementation of the new standards should proceed as rapidly as transition can be effected, and that inspection should be governed accordingly. They recommend, however, that for the time being neither the new nor the old Classes as they apply to screws, bolts, nuts, and similar threaded fasteners, should be mandatory except for specific applications agreed upon by consumer and producer."

Technishorts . . . .

INTERNATIONAL STANDARDS: ASA Sectional Committee B1, on Standardization and Unification of Screw Threads, has accepted the invitation to be represented at the Conference of the International Organization for Standardization in Paris, June 28-30, 1949, to consider establishment of an international screw thread system. The Committee, co-sponsored by SAE and ASME, is sending a delegation consisting of: G. S. Case, Lamson & Sessions Co., chairman; I. H. Fullmer, National Bureau of Standards; R. F. Holmes, AC Spark Plug Division, GMC; and W. H. Gourlie, Sheffield. The delegation has been instructed to offer and support adoption of the principles of the unified screw thread, upon which agreement already has been reached among Great Britain, Canada, and the United States.

AERO SPARK PLUGS: Present equipment is satisfactory for testing new spark plugs (for aircraft engines) and reconditioned plugs, provided all of the coating has been removed from the insulator. This recently was agreed upon in discussion by the Spark Plug Testing Procedure Subcommittee, of the SAE Ignition Research Committee. But this group feels none of the present cleaning processes is suitable. Only way to remove completely all deposits, committee members noted, is to separate the insulator from the spark plug and to remove the coating while the plug is disassembled.

Dilution Aids Lubricant Flow

WINTER proving ground tests in Alaska proved that flow characteristics at -40F could be improved by diluting engine lubricant with 20% naptha or gasoline, the final report on "Low Temperature Characteristics of U. S. Army Heavy Duty Oils," Sept. 7, 1948, discloses.

The Low Temperature Characteristics Group, working on Motor Projects of the Coordinating Lubricant Research Engine Oil Division was asked by the Army Ordnance Department to provide all necessary information on the pour point, viscosity, and pumpability of U. S. Army Specification 2-104 SAE 10 and 30 oils, with and without diluents.

A second phase consisted of developing a laboratory research technique for measuring flow characteristics of these oils.

Additional work was done to simplify the laboratory stable pour point technique and to obtain better correlation with actual field storage results.

Army specification gasoline and ASTM precipitation naphtha were equally satisfactory. Diesel fuel and kerosene, however, did not prove to be satisfactory as diluents.

With 20% gasoline dilution vehicles operating in Alaska showed no bearing failures, engines were clean, and starting was easy. Without this dilution there were cases of bearing failures because of lack of lubrication.

Cooperating laboratories were Atlantic Refining Co., Kendall Refining Co., National Bureau of Standards, Socony-Vacuum Laboratories, and Standard Oil Development Co.

This report, CRC-231, has 26 pages including 6 tables and 10 charts, and is 8½ × 11 in. Price $1.50 to SAE members, $3.00 to nonmembers; available from the SAE Special Publications Department, 29 West 39th St., New York 18, N. Y.

Small Sample Fuel Rating

TWO techniques for rating small samples of gasoline are reported in "Report on Rating Small Samples of Motor Gasoline, May 21, 1948," released by the Coordinating Research Council, Inc. Work was done by the Small Sample Rating Group working on Detonation under the Coordinating Fuel & Equipment Research Committee.

One of the techniques uses constant maximum knock fuel flow and the other uses a continuously variable fuel flow.

Both use engines in standard form with suitable alterations in the carburetor to minimize quantity of fuels.

In Technique A a small zenith carburetor float chamber and a special fuel bowl replace the standard carburetor bowl and float chamber. Ratings are obtained using the conventional constant level setting.

Technique B uses variable air-fuel ratio. An auxiliary fuel tank is attached to the carburetor in such a position that fuel-well readings approximately ½ in. below the maximum knock can be obtained.

The report, CRC-232, has sixteen 8½ × 11-in. pages, including two drawings and five tables. Price $1.00 to SAE members, $2.00 to nonmembers; available from the SAE Special Publications Department, 29 West 39th St., New York 18, N. Y.

How Diesel Fuels Burn

Excerpts from paper by

MARTIN A. ELLIOTT

Research and Development Branch, Bureau of Mines

(This paper will be printed in full in SAE Quarterly Transactions)

DIESEL fuel combustion involves both physical and chemical processes which operate under exceedingly heterogeneous conditions. They make experimentation difficult and complicate interpretation of results. Despite this, it is possible to explain most of the observed phenomena and to formulate a satisfactory qualitative description of the combustion process in the diesel engine.

The combustion of diesel fuel is accomplished in two stages: (1) the ignition delay stage and (2) the inflammation stage. The ignition delay stage comprises a period of physical delay, during which a suitable mixture of fuel and air is being formed, and a period of chemical delay, during which preflame oxidation reactions that eventually lead to ignition are occurring.

During the inflammation stage, extensive chemical reaction occurs and the potential energy in the fuel is released. These stages of combustion have chronological significance for a particular fuel particle; but there is no delineation of stages in the process as a whole because fuel is being injected while combustion is in progress.

During the period of physical delay, a jet of fuel traveling at a high velocity is broken up into drops of the order of 10 to 20 microns in diameter (0.01 to 0.02 mm). Under the conditions existing in the diesel engine, drops of this size will vaporize in about 1 to 2 millisec. Fuel and air mix as a result of the relative velocity between vaporizing drops and air and as a result of turbulence in the combustion chamber. The fuel-air mixture is exceedingly heterogeneous and concentrations of fuel ranging from 0 to 100% may exist in small regions.

During the period of chemical delay, stepwise oxidation reactions are occurring by a mechanism involving chain reactions. The rate of these reactions accelerates progressively until ignition or inflammation occurs. Average rate of reaction is increased (ignition delay reduced) by increasing temperature, pressure, or partial pressure of oxygen.

Cetane number of a fuel is a measure of its chemical reactivity and is, therefore, an indication of the extent of chemical delay. However, it is not possible to attach quantitative significance to cetane number unless the fuel has been tested in the environment in which it is to be used.

When inflammation occurs, the fuel-air mixture is exceedingly heterogeneous, just as in the delay period, and both oxidation and thermal decomposition reactions are occurring. There are definite indications that the average rate of the oxidation reaction depends upon fuel-air ratio and average oxygen concentration and that the rate of the oxidation reaction increases with increasing turbulence.

Products of incomplete combustion—such as carbon monoxide, aldehydes, and smoke (unburned fuel or free carbon)—are an excellent criterion of the efficiency of the combustion process. Under locally overlean conditions or when preflame oxidation reactions are chilled, carbon monoxide, free carbon, and aldehydes (to a limited extent) are formed.

Considering the combustion process broadly, there are certain points that warrant particular emphasis. The cetane number of a fuel is basically a measure of its chemical reactivity or chemical delay. Under many conditions of use, chemical delay is not the rate-determining step and the length-of-delay period may depend chiefly upon physical factors involving atomization, distribution, and vaporization of the fuel in the particular environment in which it is being used.

Cetane number may be related to certain performance factors during inflammation; however, generalized correlations are not possible because of the effect of other variables, such as volatility.

Therefore, it would seem desirable to obtain more basic information on the performance of fuels during the inflammation period, particularly on the fundamental factors affecting reaction rate. (Paper "The Combustion of Diesel Fuel," was presented at SAE Annual Meeting, Detroit, Jan. 13, 1949. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

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About

H. B. ORR, vice-president in charge of sales at Universal Products Co., Inc., Dearborn, Mich., was recently elected a director of the company. He joined Universal in 1939 and previous to that was with Chrysler Corp. as general sales manager of the Airtemp Division.

F. H. BOOR has announced the opening of a gear engineering office in Lafayette, Ind. He was chief engineer of Fairfield Mfg. Co. of Lafayette for more than 20 years and was in charge of gear and tool design, purchasing of special tools, experimental and research work. Boor is a graduate engineer from Purdue University, having completed his engineering degree in 1925.

S. FLOYD STEWART, executive vice-president of the Leece-Neville Co. since August 1946, was recently elected president of the organization by the board of directors. He succeeds the late **B. M. LEECE**, who died last December. Stewart joined Leece-Neville in 1936 as a research engineer.

LEE DOUGLAS has been named chief engineer with the Piasecki Helicopter Corp. in Morton, Pa. Formerly he was chief engineer and general manager of Kellett Aircraft Corp., North Wales, Pa. He joined Kellett in 1944 and prior to that he was associated with the Johnsville Plant of Brewster Aeronautical Corp., Bell Aircraft Corp., and Seversky Aircraft Corp. He is a member of SAE Committee S-2, Helicopters.

HOWARD F. FRITCH, assistant to to the president of the New Haven Railroad and president of the New England Transportation Co., has been elected president of the Connecticut Co. He will assume his additional duties immediately. The Connecticut Co. is a New Haven Railroad bus operation affiliate which provides bus transit facilities in New Haven, New London, Hartford, Stamford, and other Connecticut communities. Fritch is a past-chairman of the SAE New England Section.

PARKER K. REMKUS is now engineering coordinator for the Bureau of Engineering, Department of Airports, City of Los Angeles, Municipal Airport. Formerly he was assistant project administrator at Lockheed Aircraft Corp., Burbank, Calif.

JOHN W. JOHNSON, consulting engineer, is the author of "Diesel Engines," the second edition of which recently was published by the McGraw-Hill Book Co., Inc. This book covers automotive, marine, railway, industrial, and stationary diesel powerplants. It describes them, tells how to select and operate them in the light of current practice. Several chapters are devoted to trends in component design, including combustion chambers, fuel injection, cooling, fuel, and lubricating systems.

S. E. RUSINOFF, assistant professor of mechanical engineering, Illinois Institute of Technology, is the author of "Mathematics for Industry," which recently was published by the American Technical Society. Presenting in simplified form the mathematics of every-day practical engineering and machine shop practice, this text book covers industrial applications of arithmetic, algebra, geometry, trigonometry, and gears. In addition to problems shop mathematics of screw threads and logarithms. It also delves into the (together with answers) involving engineering computations, the book includes tables of trigonometric functions and logarithms.

ROBERT W. SEAVEY is an engineer with Paragon Gear Works, Inc., in Taunton, Mass. He had been research engineer at Ford Motor Co., Dearborn, Mich.

ROBERTSON

STONE

D. D. ROBERTSON has been promoted to sales manager of the Spicer Mfg. Division of Dana Corp., Toledo. He joined Spicer in 1937 as sales engineer and since 1943 has served as assistant sales manager. He is a past treasurer and vice-chairman of the SAE Philadelphia Section. **WILLIS L. STONE** succeeds to the post of assistant sales manager.

Members

GEORGE B. FRAUMANN has been appointed parts sales manager of Chrysler Export Division, Chrysler Corp. and will supervise the furtherance of parts and accessories sales. He entered the Export Division in June, 1947, and joined the Parts Department in January, 1948. During the war, Fraumann joined the Supply Mission of the Chinese Government as a transportation consultant in the Far East.

C. E. DALTON has been appointed general manager of the Overseas Distributors Branch, Ford Motor Co. This branch is a new unit of Ford and is located in Jersey City, N. J. It is primarily a sales agency for built-up vehicles shipped by the five Ford manufacturing plants throughout the world to markets not regularly served by assembly plants.

E. ROBERT LEEDER is now vice-president, a member of the board of directors, and a member of the operating committee of Gar Wood Industries, Inc., in Wayne, Mich.

FRANKLIN H. FOWLER, JR., has become assistant editor of Product Engineering, published by McGraw-Hill, New York City.

WILLIAM W. ZIEGLER, now sales representative for Alken-Morray Corp. in New York City, had been connected with Krieger Steel Sections, Inc., Long Island City, N. Y.

HORACE E. MEAD, recently became shop foreman for the Douglas Oil Co. in Paramount, Calif.

CHARLES N. HASKINS is now truck manager for Bonday Motors, Maywood, Ill. Previously he was research engineer at Continental Aviation & Engineering Corp. in Detroit.

ROBERT S. SCHUYLER is assistant to the director of truck sales at Dodge Bros. Corp., Detroit. He was formerly district truck manager in the Los Angeles region for this company.

GEORGE B. MOSELEY has been assigned to supervise stamping and contract manufacturing sales at the Firestone Steel Products Co., Akron, Ohio. He has been in stamping sales work a number of years and recently was employed by the Globe Stamping Division of the Hupp Corp. where he served as sales manager of the contract Manufacturing Divison.

MARLBORO K. DOWNES is now district airport engineer for the Airports Branch of the Civil Aeronautics Administration, Richmond, Va.

W. E. SHILTON recently left England to take up an appointment with Messrs. Freighters, Ltd. of Melbourne, Australia.

GEORGE H. DICK is a junior engineer with Fairbanks Morse & Co. in Beloit, Wis.

PHILIP E. B. VAILE has been appointed assistant director of research at Anglamol, Ltd., Hazelwood, Derbyshire, England. Vaile has been awarded first prize for the best paper presented before the Graduate's Section of the Institution of Mechanical Engineers in 1948. His paper, "Research on the Compression Ignition Engine and Its Fuels" was presented on April 24, 1948.

JAMES S. RICKLEFS has been elected president of the California Helicopter Association, recently formed by the major helicopter operating companies on the West Coast. The purposes of the association are the dissemination of helicopter information, organized promotion of the helicopter, mutal assistance and cooperation, and exchange of ideas. Ricklefs is associated with Rick Helicopters, Inc.

E. J. GODIN is now sales engineer with the Detroit office of Eclipse Machine Division of Bendix Aviation Corp., Elmira, N. Y. He was previously electrical engineer, Reo Motors, Inc., Lansing, Mich. Godin is 1948-1949 vice-chairman of the SAE Mid-Michigan Division.

J. V. BASSETT has been appointed chief engineer of the Bus & Truck Brake Lining Division, Raybestos-Manhattan, Inc., Fisher Building, Detroit.

ARTHUR G. WINTER has become sales engineer in Detroit for the Rochester Products Division of General Motors Corp., Rochester, N. Y. Prior to this position he was project engineer at Holley Carburetor Co., Detroit.

JULIAN CHASE, directing editor of Chilton Co.'s Automotive Division, has retired after 50 years in automotive magazine publishing. He was also a vice-president and director of the Chilton Co. and editor of "Automotive Industries". A member of SAE since 1908, Chase became editor of "Horseless Age" in 1904, following graduation from Brown University (where he was a star football player), and several years in automobile and parts company work. He came to Chilton Class Journal Co. when that organization bought "Horseless Age"—which later became "Automotive Industries". He is a past-president of the National Conference of Business Paper Editors and a member of the board of directors of the Automobile Old Timers.

JAMES R. CUSTER, formerly associate editor, has been named editor of "Automotive Industries". Associated with the publication since 1941, Custer was graduated from the Engineering College of the University of Detroit in 1932. For the next four years he engaged in aircraft engine research work with Continental Motors Corp., joining Chevrolet's engineering department in 1936. There he was assistant in charge of the Technical Data Section.

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R. F. SANDERS has been appointed experimental engineer for Chevrolet, Division of General Motors Corp., Detroit. His new responsibilities include being in charge of the Experimental Department and Laboratories in Detroit and Proving Ground test for Chevrolet at Milford.

CHARLES E. HEYWOOD has been appointed service engineer for the Elastic Stop Nut Corp. of America in Union, N. J. He was previously associated with the Chance Vought Division of United Aircraft as standards engineer and also acted as NASC representative for that company. Heywood served on the Headquarters' Staff of the SAE for many years.

JOHN W. FLEISCHER will head the new Motor City sales district of General Electric's Lamp Department with headquarters in Detroit. Since 1932 he has been assistant manager of the Michigan sales district. Fleischer joined the General Electric Lamp Department at Detroit in 1920 in a sales capacity.

CHARLES W. PERELLE, former head of Gar Wood Industries, Inc., was recently elected president of the ACF-Brill Motors Corp. His resignation as president of Gar Wood Industries was announced in the March issue of the SAE Journal.

HAROLD S. VANCE, Studebaker president and board chairman, said recently: "Industry wants men and women who know how to learn, who have enthusiasm and initiative. . . . who have faith in American democracy. . . . who recognize that before there can be more to divide, more must be produced." The occasion: a talk to the Illinois-Indiana Section, American Society for Engineering Education.

HARVEY S. FIRESTONE, JR. board chairman of Firestone, broadcast a goodwill message to Brazil last month in which he said that Firestone is so confident of Brazil's future it is again planning to expand its operations there. He spoke over the State Department's "Voice of America" program during a ceremony welcoming President Enrico Dutra to American shores. Firestone was recently elected president of the new peacetime United Service Organizations, Inc., at the first meeting of the USO's incorporators in New York City.

A. J. BLACKWOOD, assistant director, Standard Oil Development Co., Elizabeth, N. J., spoke on "Effect of Recent Trends in Automotive Developments on Future Quality and Volume of Gasoline" before the National Gasoline Tax Conference, Eastern States Group, in Baltimore, May 13. On May 20 he spoke on "Future Gasoline and Diesel Developments" before the New Jersey Motor Bus Association, Inc., Atlantic City.

J. CARLTON WARD, JR. made the fourth address on March 7 of a series sponsored jointly by the National Air Council and the Library of Congress. Just as our military services engage in war games, he said, key industrial units need similar small-scale rehearsal as a practical test of their efficiency under emergency mobilization conditions.

W. M. BROWN, truck project engineer, Kenworth Motor Truck Corp., has just returned to Seattle following a 10-week trip to Saudi Arabia where he inspected the operations of Kenworth equipment in the oil fields of that area.

A. J. MAURICE OUSTALET, JR. has become sales engineer at Auto Painting & Repairing Co., Inc., New Orleans, La.

S. R. SKELTON recently became general manager of the Saturday Night Press in Toronto, Ont., Can. He had been affiliated with the Goodyear Tire & Rubber Co., Ltd., in New Toronto.

J. J. FRANZMAN is now connected with the Cities Service Oil Co. in New York City.

T. F. WALKER is the new vice-president in charge of production for the Kent-Moore Organization, Inc., supplier of service tools to General Motors, Nash, Studebaker, and Hudson. He joined Kent-Moore in 1940, and prior to that was associated with Pontiac and Buick.

A. P. FONTAINE, of University of Michigan, was recently elected president of Radioactive Products, Inc.

H. M. DENYES, former sales engineer, has been made sales manager of Gemmer Mfg. Co.

DONALD ALEXANDER, vice-president of the Budd Co. has resigned from the company and plans to retire from active business. He has been connected with Budd since 1919 and will continue as a member of the board of directors.

J. RODERICK McKENNA is master specialist of carburetors for Eastern Airlines, Inc., in Miami, Fla.

MELVIN N. OSBORN is now senior layout draftsman at the Allison Division of General Motors Corp., Indianapolis, Ind. Prior to this post, he was project engineer at the Wayne Pump Co., Ft. Wayne, Ind.

STUART H. SMITH, formerly assistant district manager for SKF Industries, Inc., in Detroit, has been appointed district manager for the company in Cincinnati.

DONALD W. SMITH has joined the Modine Mfg. Co., Racine, Wis., as a sales engineer in their Automotive Division.

ROBERT M. BRAM has become an aeronautical design engineer for the Goodyear Aircraft Co. in Akron, Ohio. He had held a similar position with Chance Vought Aircraft Co. in Stratford, Conn.

MAHESH GOVIND has joined Hindustan Motors, Ltd., Calcutta, India, as a production engineer, Machine Shop.

CHARLES M. HANNUM has become a general partner in the firm of A. J. Brandt Co., Detroit. He has been with the company for 16 years.

THOMAS L. HOLBROOK has been appointed Westinghouse lamp sales engineer with headquarters in Detroit. He will work principally with manufacturers of equipment using automotive type bulbs in Detroit, Chicago, Cincinnati, Indianapolis, and other points. Since May, 1946, he has been staff assistant to the manager of operations, Kaiser-Frazer Corp., and previously served as chief experimental engineer for that company. During World War II he was assistant to the chief engineer at the Detroit Tank Arsenal, operated by Chrysler Corp. Holbrook is one of the orginators of automobile instrument dial edge lighting and also developed a headlight aiming machine.

W. R. TOEPLITZ and **SAMUEL S. CONNOR** have been elected to the board of directors of the Bound Brook Oil-Less Bearing Co. in Bound Brook, N. J.

FRANK N. PIASECKI, president of Piasecki Helicopter Corp., Morton, Pa., addressed the First International Aeronautical Industries meeting at Paris, France on May 12. His paper is entitled "Engineering Problems of the Helicopter". While in Europe, Piasecki will attend the British Industries Fair in London and visit helicopter and aircraft plants in England, France, Switzerland, Italy, and Spain.

KENNETH G. Mac KENZIE of the Texas Co., in New York City was one of three veteran petroleum technologists to whom certificates of appreciation were awarded by the American Petroleum Institute at a dinner of the group's refining division in Houston, Tex.

Recently graduated from Purdue University, West Lafayette, Ind., **D. R. COPPLE** is an industrial engineer with Western Electric Co., Speedway City, Ind.; and **WILLIAM L. SWANTON** is a customer engineer (trainee) for International Business Machines in Chicago.

ROBERT B. DOUGLAS was elected president of the American Society of Tool Engineers. He is president of Godscroft Industries, Ltd., Montreal and is the first Canadian to head the Society.

JAMES W. MOHR, SR., is research and development engineer with Kiekhaefer Aeromarine Motors, Inc., Fond du Lac, Wis.

JEROME L. MELTZER is flight engineer with American Airlines, Inc., Dallas, Tex.

EARL D. LOCK is senior draftsman for the Goodyear Aircraft Co. in Akron, Ohio.

ERIC KLAPPER is now radio engineer at the National Bureau of Standards, Washington, D. C.

FRANK CLIFFORD THOMPSON is an engineer with North American Aviation, Inc., Inglewood, Calif.

S. BRENT GIRDLER, JR. is now an engineer—sheet and tin mill and relief foreman—for the Columbia Steel Co. in Pittsburg, Calif.

C. A. THORNBURGH, JR., is a draftsman for North American Aviation, Inc., Inglewood, Calif.

ALBERT H. GILBERT has become head of industrial design for the Lavers Engineering Co., Chicago. He had been chief engineer at Brad Foote Gear Works, Inc., Cicero, Ill.

WAYNE TROYER is a student engineer at the Oil Well Supply Co., Oil City, Pa.

RICHARD A. FLUME is now connected with Braniff Airways, Dallas, Tex.

Recently graduated from the College of the City of New York, **MARIO ROBERT SKROKOV** is a junior mechanical engineer for the California Texas Oil Co., Ltd., in New York City; and **PAUL SLYSH** is a junior engineer for the American Machine & Foundry Co. in Brooklyn, N. Y.

JOSEPH A. RIZZO has become owner of the General Merchandise & Equipment Co., located in Wheatland, Pa.

LEON ADELMAN is now sales engineer with the Sesco Engineering & Supply Corp. in North Kansas City, Mo.

JOHN BORLAND recently became chief engineer of the Oliver Corp., Plant No. 2 in South Bend, Ind.

RICHARD F. GOMPERTZ is now chief of the Rocket Branch at the Air Materiel Command, Muroc Air Force Base, Muroc, Calif.

WILLIAM A. CLEGERN has become engineer in charge of operational powerplant Group, Consolidated Vultee Aircraft Corp. in Fort Worth, Tex. Previously he was powerplant engineer in the Thermo Group with the same company at their San Diego Division.

JAMES H. McMANUS recently became eastern sales manager for O. M. Edward Co., Inc., in New York City. He was previously New England manager for this company.

ERVIN L. DAHLUND has become chief engineer of the Diesel Engineering Department of Fairbanks, Morse & Co. in Beloit, Wis. His previous position was secretary, Chief Engineer's Committee of the Diesel Engine Manufacturers Association, Chicago.

WILLIAM C. SERVIS is now connected with Chase Aircraft, Inc., Trenton, N. J.

ALLEN CRUCE GARNER is sales manager of Allen Garner Chevrolet Co. in Poplar Bluff, Mo.

STEPHEN L. SHIRA recently became service and sales representative for the Scintilla Magneto Division (Bendix Aviation Corp.), in Sidney, N. Y. He was formerly with Thomas A. Edison, Inc., West Orange, N. J.

ROBERT BOTHFELD has joined the Fisher Body Division of General Motors Corp. in Euclid, Ohio.

CHARLES M. FLUKE is now assistant to regional coach manager, West Coast, for the White Motor Co. Coach Division. He was formerly coach regional service engineer in New England for this company.

M. W. CLINE recently became vice-president of purchasing for the Clarkson Construction Co. in Kansas City, Mo.

OTTO C. REICHEL is now a designer for the Caterpillar Tractor Co. in East Peoria, Ill. He formerly held a similar position with R. G. LeTourneau, Inc. in Peoria, Ill.

S. A. GUNNESS has been appointed manager of Lubricating Oil Sales for the Deep Rock Oil Corp. in Chicago. He was previously assistant manager of Lubricating Oil Sales.

OBITUARIES

IRA HAND

For 38 years executive secretary of the National Association of Engine & Boat Manufacturers, Ira Hand died April 26 in Sarasota, Fla., after a brief illness. He was 69 years old.

A veteran of the Spanish-American War, Hand attended Fordham University and for several years played professional football. He managed a professional team, the Mohawks, before becoming associated with the motor and sail boat industry.

His gift for showmanship was displayed annually at the National Motor Boat Show in Grand Central Palace, where he successively planned and managed the huge displays of large cabin cruisers, big marine engines, and a wide range of boating accessories. Frequently he was on the job around the clock for several days directing the displays prior to show openings.

He wrote numerous articles about the industry, in which he became a leading figure, for newspapers and magazines. He became an affiliate member of the Society 30 years ago.

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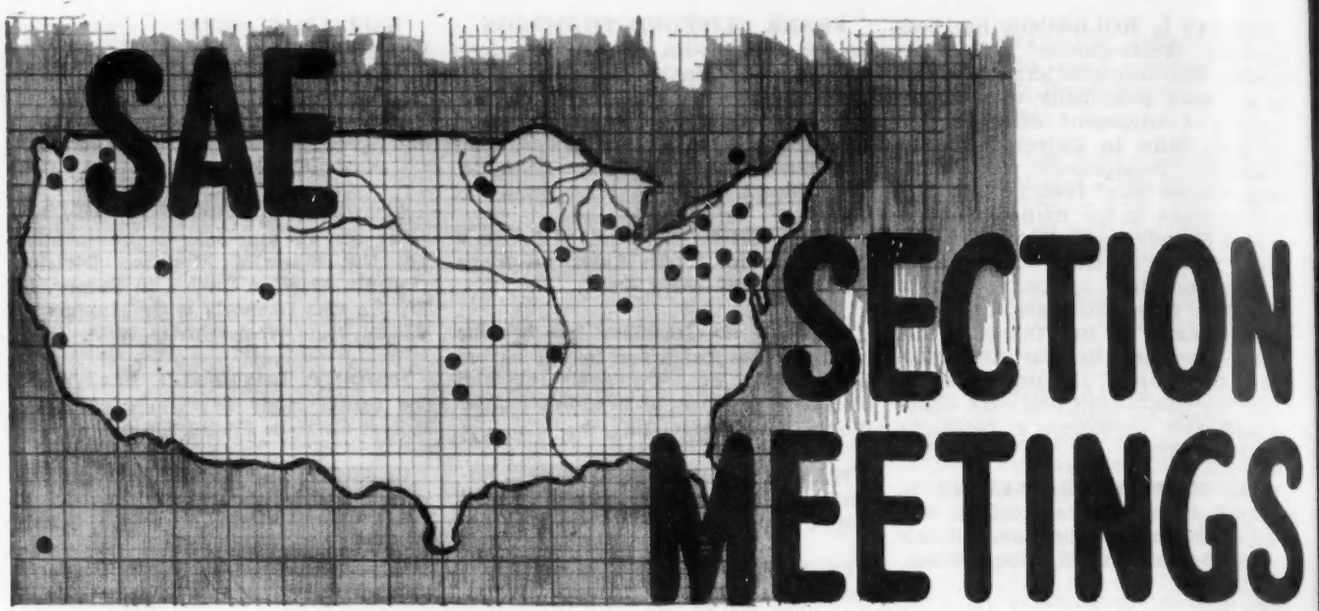

Find New Applications for New Transmissions

• Colorado Group
D. H. Lamb, Field Editor

April 12—The rate of development of hydraulic transmissions is extremely fast, reported **Robert M. Schaefer,** chief engineer of commercial transmission department, Allison Division, GMC.

He proved his contention with news of hydraulic transmissions now in use and some proposed for the future.

Use of a torque converter with the Allis-Chalmers HD-19 crawler tractor reduced the number of speeds required from six to two, he said. He pointed out also that an extra feature obtained in this installation is the ability to operate the engine at a higher power factor, enabling the operator to get more work done.

Speaking of the many applications of hydraulic drives in tanks and other Army equipment, Schaefer said, "Reduction of fatigue and partial availability of the driver for additional functions in combat was an extra the armed forces were quick to accept. At the end of the war, hydraulic transmissions were used on 90% of the tank productions."

On track laying tractors the advantage of the torque converter was exemplified in his statement, "Results of comparative tests indicate 22% more dirt moved at 50% more fuel but at 6% lower overall cost in the converter-equipped tractor. This ability to do more work actually means that on this size tractor the extra cost of the hydraulic transmission can be earned back in 60 to 90 days."

He added that with dirt moving machinery, over a one-week period the average values showed that with a standard transmission 72 yd per hr were moved with a fuel consumption of 5.15 gal per hr. Under identical tests the converter-equipped units moved an average of 99 yd per hr with a fuel consumption of 8.6 gal per hour. This was a 37% gain in work accomplished. The fuel consumption was 67% greater, but the fuel cost is only 12% of the operating cost.

Applications of hydraulic units for oil field machinery, logging, equipment, railway switching locomotives, etc. were discussed. In closing, Schaefer pointed to the future and reported that new approaches are continuously being opened for improved performances and more work done . . . extra features are being obtained all the time. He mentioned there will also be new ways of combining torque converters with hydraulic transmissions. In his opinion, the trend, as evidenced by manufacturers and users, clearly points to the further use of hydraulic transmissions.

Pencil Battles Eraser in Auto Engine Design

• Washington Section
J. T. Duck, Field Editor

April 15.—"Designing an automobile engine is a battle between the pencil and the eraser," SAE President **Stanwood W. Sparrow** told the Washington Section. In his talk, "My Friend the Engine," Sparrow outlined the problems involved in designing an engine. Illustrating his discussions with many slides, he traced the development of an engine from its conception as an idea to the production line.

The battle between the pencil and the eraser begins in the drafting room, Sparrow explained. Here the plans for an engine must be laid out to meet the projected requirements of the automobile in which it is to be installed. After the engine and its components have passed the "sliderule tests," shop models are built to maximum and minimum tolerances to be expected on the assembly line. The performance of these experimental models is charted. The manifold must be modified as necessary for efficient distribution of fuel and good volumetric efficiency. The cooling system is carefully analyzed to eliminate local overheating. Spark plugs of a satisfactory heat range must be selected. Brake and friction horsepower is determined over a practical range of operating speeds—first with all standard accessories, then without various accessory units. Endurance runs are made to show the service performance of engine components and accessories. Other tests show the fuel consumption of the engine under various operating conditions.

When the laboratory performance of an engine has been found satisfactory, it still must be tested installed in the automobile. On the proving ground it is operated over a great variety of road conditions. Its hill-climbing ability, acceleration, and top road speed are measured. The life and service operating characteristics of various components are also determined in extended periods of road operation.

The speaker was introduced by

Southern New England Section welcomed back an erstwhile neighbor, Andrew Kalitinsky, now chief engineer of the NEPA Project at Oak Ridge and formerly a development engineer with Pratt & Whitney Aircraft, at the April 27 meeting. Kalitinsky delivered his paper: "Atomic Power for Propulsion of Aircraft" before a large audience on the Trinity College campus. Here (left to right) Past-Chairman Richard C. Molloy, United Aircraft's assistant director of research, and Kalitinsky chat with Section Chairman David E. Waite, Wallace Barnes Co.

Speaker A. T. Colwell turns to Northwest Section Chairman R. E. Fleischer (standing, left) for a word of advice that Vice-Chairman W. J. Colson (standing, right) and SAE staff man E. W. Rentz enjoy at the dinner preceding the April 27 meeting

Baltimore Section members sit back and prepare to hear D. Roy Shoults discuss reasons for using turbine powerplants in transport aircraft at their March meeting. Shoults is vice-president of Glenn L. Martin Co.

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Technical Chairman W. K. Knauf who recalled his previous association with Sparrow when the latter was chief of the automotive power plants section at the National Bureau of Standards during the early twenties.

Cadillac Engineers Discuss '49 Engine

• Pittsburgh Section
Murray Fahnestock, Field Editor

April 26—**H. F. Barr's** presentation of the national-meeting paper "The New Cadillac Engine" by him and **E. N. Cole** drew animated discussion.

J. M. Campbell, head organic chemist of GMC, presented a slide showing the relation between octane ratings and compression ratios. Campbell, C. F. Arnold, Cadillac's assistant chief engineer, and Barr formed a panel to answer questions from the floor. C. J. Livingstone of Gulf Research & Development Co. served as technical chairman.

SAE Past-President R. J. S. Pigott called attention to one of the slides showing that Cadillac engineers had done more to improve the performance by making mechanical changes than the chemists of the oil refiners had been able to do by making changes in the composition of the fuel.

Machinery is more responsive to improvement than nature, Pigott observed. He brought out also that the saving of 200 lb in the Cadillac engine is equivalent to a saving of three times that in total weight and performance value of the car.

Commenting on valve action, in answer to another discusser, Pigott said that much of the valve cooling is due to heat transfer from the valve to its seat. Much difficulty in racing engines at high speeds he credited to inadequate contact between valve and seat due to valve bounce.

Murray Fahnestock, editor of "Ford Field," recalled that it was Cadillac that first demonstrated the accuracy that made mass production profitable when it won the Dewar trophy in 1906. Cadillac sent three cars to England, where they were disassembled, their parts scrambled, then reassembled. All three cars ran perfectly —a most notable achievement in those years.

A request for comparisons between the 1949 Cadillac and the 1949 Oldsmobile brought the answer that General Motors believes in free competition. Individual divisions do their best. All divisions have access to the same research laboratories and are

Cont. on page 87

SAE Section

These biographies are part of the series on 1948-1949 Section Chairmen

WALKER

. . . . of Kansas City

During the 13 years of his career, Robert A. Walker's engineering interests have fanned out from fuels to powerplants to complete aircraft.

He joined the Standard Oil Co. of California as a research engineer on automotive and aircraft fuel development in 1936 after his graduation from the University of California with a degree in mechanical engineering. His work included laboratory engine testing, road testing of automotive fuels, and flight testing of aircraft fuels.

This led in 1941 to a job with Trans World Airline at Kansas City, Mo. During his first three years with TWA, Bob was in charge of aircraft powerplant engineering. For a period from 1943 through 1945, he was also in charge of the Army Air Forces-Coordinating Research Council flight tests on aviation fuel volatility. TWA conducted these tests under contract with Wright Field, using C-49 and C-46 twin-engine transports.

Bob became TWA's superintendent of aircraft engineering in 1945 and a member of the staff engineering group early the next year. He is concerned with aircraft powerplants, structures, and systems from the standpoint of airline operational and maintenance engineering problems. He studies characteristics of newly designed aircraft to determine what types of aircraft should be purchased for future fleets.

Occasional check flights to distant parts of the world and vacation travel provide fascinating subjects for his photography. Bob experiments with his photographic equipment and builds furniture in his home workshop. He has assembled an excellent high-fidelity radio and phonograph system in a cabinet of his own design and construction.

—Willard R. Beye, Field Editor

FLEISCHER

. . . . of Northwest

Russell E. Fleischer applies to SAE work the same geniality and enthusiasm that put him ahead in other fields.

The "Sarge" organized a group of able committee chairmen who, under his leadership, have provided the kind of meetings that boost attendance figures. Besides, his Section has established an active aircraft group at the Boeing Airplane Co. and a student group at the University of Washington.

Fleischer started with Colyear Motor Sales Co. nearly 30 years ago. Now he is district manager of the Seattle branch. He is a leader in Seattle's civic life, too.

He served in the infantry on the Mexican border in 1915 and became top sergeant of infantry during World War I in France.

Being fond of boating, he spends considerable time cruising the waters of Puget Sound on his yacht, the "Shirley Marie," usually with the throttle open wide. His other hobbies are hunting and fishing.

—Kenneth A. Short, Field Editor

Chairmen

O'CONNOR

. . . . of Buffalo

Barney O'Connor is an hydraulics expert with a broad inventive streak.

He designed a recoil mechanism that increased the rate of fire of the 50 calibre machine gun and a viscous torsional vibration damper that is now widely used in automobile and diesel engines.

His stress analysis work on shimmy dampers for airplane tricycle landing gear brought about many changes in design and materials.

All three projects were carried out for Houdaille-Hershey Corp.'s Houde Engineering Division, which O'Connor serves as assistant chief engineer. Before working there, he designed local cables for Western Electric and studied electrical engineering at the Newark Technical School.

Barney has held section committee chairmanships and represented his section on the national nominating committee. The paper on the viscous torsional vibration damper that he presented before his section ran in the first number of SAE Quarterly Transactions.

In the summer, Barney likes to play a fast game of tennis. When Buffalo's winter weather drives him indoors, he takes to ping pong. He and Mrs. O'Connor have one son and three daughters.

—Ben Fuente, Field Editor

EVANS

. . . . of Washington

The Sheldon Spring and Axle Co. started something when they assigned Harold W. Evans to help design the Class B trucks for the Quartermaster Corps in 1917. He's been connected with the Army ever since.

The Army soon commissioned him a lieutenant in the Motor Transport Corps, and he remained with Motor Transport throughout World War I. Later he transferred his allegiance to the Ordnance Department, where he has compiled a record of 32 years of continuous service. Most of that time he has spent in development and manufacture of tanks and combat vehicles for the Army. His assignments have taken him to various installations of the Ordnance Department, including the Rock Island and Detroit Arsenals. During World War II, he was stationed at Detroit in the Tank-Automotive Center.

He's now chief of the tank and automotive branch, Ordnance Research and Development Division, Office of the Chief of Ordnance.

The War Department's meritorious service award for his work during the last war is one of several commendations and citations he has received.

Before his Army work, Evans worked for Sheldon Spring and Axle, the Crane-Simplex Co. in New Jersey, and the Matheson Motor Car Co. at Forty-Fort, Pa. He joined SAE in 1917 and has been active ever since.

He was born, raised, and educated in Pennsylvania. Every fall he returns for a few weeks and bolsters his reputation there as a big-game hunter. He and Mrs. Evans have two sons, both engineers, and two grandchildren.

HASTINGS

. . . . of Canadian

Warren B. Hasting's chairmanship of Canadian Section climaxes the long series of his services to SAE and to the Canadian automotive industry in general.

He joined SAE in 1921, and when Canadian Section was founded in November 1921, he became its first secretary. It was he who read the resolution proclaiming the newly formed section at its inaugural meeting His associations then and in later years with late Robert H. Coombs, father and first chairman of the Section, and the late Col. A. S. McArthur, first vice-chairman, nestle among Warren's fondest memories.

For almost 20 years, Warren continued as Section secretary until, as he puts it, he was kicked upstairs to be vice-chairman in 1947.

Newspaper work led Warren into the automotive field. He started work with the "Sunday World" and established the large automotive section which distinguished that weekend newspaper. The public in those days was avid for news of the motor car world, and the newspaperman in Warren gave it to them in large doses—to the extent, on occasion, of a 50-page section. When the "Star Weekly" absorbed the "Sunday World," Warren went along as automotive editor.

At the same time, he was editing and managing "Canadian Motorist," the official publication of the Ontario Motor League. Warren was subsequently promoted to assistant general manager of the League and serves in that capacity today.

He authored the first Canadian primer on the motor car, "What Makes a Motor Car Go."

For many years, he managed the Canadian Automobile Association contests. He is vice-president of the Affiliated Engineers and Allied Societies and a member of the Highway Technical Advisory Board.

He is so much a part of the automotive scene in Canada that no function is complete without his presence.

—G. R. Jackson, Field Editor

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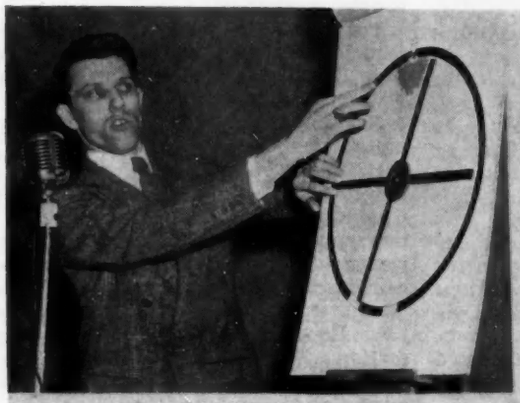
The chance to tour the Oldsmobile engine plant as part of Detroit Section's Mid-Michigan regional meeting drew 800 members to Lansing on April 5. They assembled in the Olds Engineering Auditorium, then split into small groups to view steps in producing the Oldsmobile Rocket engine. After dinner, they heard Col. Warren J. Clear talk on preparedness



To the dinner Detroit Section gave for SAE enrolled students in the area, eight students brought displays illustrating their pet engineering projects and explained them. Kenneth Colburn (upper left), University of Detroit, diagrammed a new rotating-vane type of engine. Fred Warzin (upper right), Ford Engineering School, showed his model engines. Richard Stickley (lower left), Lawrence Institute of Technology, recommended all-around bumpers for passenger cars. Fred Niehoff (lower right), General Motors Institute, described the layout of a new ball-bearing plant. Other student speakers were Charles L. Reno, Chrysler Institute of Engineering; Robert M. Lynas, Detroit Institute of Technology; George Tuttle, University of Michigan; and Kenneth Bradley, Michigan State

profiting by the development of the Kettering engine. All divisions profit also from the leadership of the division turning out the best design.

In answer to R. M. Welker of Gulf Refining Co., it was said that the temperature of the crankcase oil averaged from 80 to 90 F above that of the water in the cooling system, which would not rise over 235 F, even under sustained full loads.

Charles Woods of West Penn Power asked what increase in power would be available when, and if, 100-octane fuel became available. While 100-octane fuel is not likely to be available in the near future, it was suggested that increases of from 15 to 20% in power might be obtainable with suitable engine modifications and 100-octane fuel.

Because of the present difficulty in obtaining such fuel on the road, Cadillac has not provided the equipment necessary to use 100-octane fuels to maximum advantage. Regarding the use of relatively lower octane fuels than those presently recommended, the Cadillac men felt that these would be no more harmful in the '49 engine than in previous engines, because the new engine has been designed to be relatively free from detonation, and detonation is the destructive factor when low-grade fuels are used.

Regarding gasoline economy, as shown on the slides, Arnold answered a question as to a typical 2000-mile tour by saying that while the average might have been 12½ mpg for the '48 Cadillac, the new engine might be expected to deliver from 14 to 15 mph. Overhead valves seem to be a factor in causing less knock.

While the use of premium oils is recommended, the new engines do not require better oils than those presently available, the Cadillac experts said.

Detroit Entertains Enrolled Students

• Detroit Section
R. E. DeWald, Ass't. Field Editor

March 28—Detroit Section entertained local SAE enrolled students at dinner, gave eight of them a chance to air their pet engineering problems, provided some pointers on original thinking, and showed the movie "Oil Films in Action."

First of the eight student speakers was Charles L. Reno, Chrysler Institute of Engineering, who set forth the thought that the young engineer is likely to generate 99 useless ideas before he hits one good idea that pays off.

University of Detroit's representative, Kenneth E. Coburn, related his problems with a revolving vane-type internal combustion engine, illustrating difficulties in design on a demonstration board he brought along.

Robert M. Lynas explained that his pet problem and its solution grew out of an experience he had while attending his school, Detroit Institute of Technology—his car was stolen. Since then, he has designed a foolproof burglar alarm guaranteed to cause a furor, should anyone tamper with his car.

An all-around bumper to protect the fenders and flowing lines of his beautiful new automobile, reported Richard Stickley, Lawrence Institute of Technology, is the first problem he would like to tackle after finishing school.

Fred H. Niehoff, Jr., of General Motors Institute, showed his audience a plant layout of the New Departure Division. This new building was designed expressly for line production of ball bearings in high quantity with maximum accuracy, he said.

Compound engines with turbosuperchargers for high altitude flying were shown to present problems in thermodynamics and heat transfer by George Tuttle, of the University of Michigan.

Fred Warzin, Ford Engineering School, discussed his hobby, building miniature aircraft engines. He showed a 5-cyl, four-cycle radial engine and a 6-cyl, two-cycle engine with vane-type rotary pump.

Michigan State College's representative, Kenneth R. Bradley, built himself a speed boat during his high school days, he explained. He had quite a time with the exhaust pipe and the excessive vibration set up when he tried to use a flexible coupling. He found he needed supports for the drive shaft, and now that he has installed them, he has a boat that burns up the lakes.

Original thinking, according to **Frank C. Mock**, is an extremely rare phenomenon that should be nurtured and encouraged. He suggested that a young engineer, when presented with a problem, should first try to arrive at his own solution. Then, after he has carefully thought through a solution, he should be free to consult with authorities in the field. With such a starting point, the engineer will not be quickly persuaded that a certain method can not be employed merely because the textbooks of the time said it can't.

What happens to the lubricating oil in the bearings when the shaft revolves? Joseph B. Bidwell of Gen-

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eral Motors Research Laboratories answered this question with a movie entitled "Oil Films in Action." It featured a lucite model of a journal bearing. Transparent, hollow tubes drilled at intervals through the surface of the bearing to the bright red oil film, acted as manometers measuring the hydraulic pressure at these points.

The picture demonstrated that the pressure distribution in the oil film along the journal axis is parabolic, since the colored oil rises in the tubes in that pattern after the shaft starts to move. It also illustrated that a reduction of load on the shaft would drop the pressure, whereas a change in speed of journal rotation had no effect on the height of the oil in the manometer tubes. Change of viscosity of the oil likewise did not affect the pressure.

Detroit Section Tours Olds Plant

• Detroit Section
Ruth and John DeWald

April 9—The attractions of an SAE meeting and plant tour brought nearly 800 members to a regional meeting at Lansing.

The program included a technical session on the Oldsmobile "Rocket" engine, a visit to the newly tooled plant producing the engine, a reception, dinner in the Olds Engineering Auditorium, and an address on national security by Col. Warren J. Clear, U. S. Army, retired.

J. F. Wolfram, chief engineer of the Oldsmobile Division, GMC, related details of the design, construction, and performance of the new powerplant.

Machining and assembly of the engine components from rough castings to the run-in operation included many points of interest for the enthusiastic "tourists." The area in which the cylinder blocks are processed was one of the most popular spots in the plant.

Nine machines, some units being in pairs, handle these major machining operations. These are lined up in a series of "U" and "S" configurations, rather than in a straight line.

Tin-plate is used on the slipper type piston for quicker break-ins. Tin-plating of the exteriors of camshaft bearings ensures a good seat.

Machining of the cylinder heads is governed by inspection on a machine which compares the cast cavity of the combustion chamber and the desired cavity volume, with very close volume limits maintained. The instrument compares the resonance frequencies of the test and standard cavities and indicates the difference. The face machining is determined by

the volume of the combustion chamber cavity desired.

Col. Clear in his address pointed out that the United States had activated a 70-group air force prior to Pearl Harbor and that the existence of these planes did not prevent the destruction of our Pacific fleet. He further cited intelligence reports to show that, in 1944, Germany's production of war supplies was higher than before the United States entered the war. This occurred in spite of the intensive daylight bombing carried out by the Allied air forces. He emphasized that the United States, as one of the two world powers at the present time, needs all three types of military services: the air forces to provide the advance guard, the ground forces to hold positions, and the Navy to control the seas and move in troops and heavy supplies.

Jet Engine Progress Tied to Metallurgy

• Northwest Section
K. A. Short, Field Editor

April 27—Metallurgical problems and engine-control difficulties are the principal obstacles to jet engine progress, said **A. T. Colwell**, vice-president of Thompson Products, Inc.

He reported that stainless steel, sintered iron, and ceramics are being tried for gas turbine powerplant blades, buckets, and vanes. He described a variation of the lost-wax method of casting which involves frozen mercury in place of wax.

Colwell emphasized that we must develop jet engine components from noncritical materials.

Ultimate solution to jet-engine control problems, Colwell predicted, may be electronic controls. Such devices may be developed eventually to prevent burner blowouts and other operating difficulties.

Colwell quoted Gen. Joseph T. McNarney, saying that there is an entirely new concept of warfare, that any future conflict will abandon the tactics of past wars.

Guided missiles will be carried thousands of miles by long-range bombers, then released 500 or more miles from the target, to fly on, jet propelled and radar guided. Defense will include ground-to-air, proximity-detonated missiles and greatly expanded use of radar, Colwell continued.

To achieve long range, piston engines will be used in bombers, said Colwell, but all new fighters will be jet propelled.

Research, Development Get Billion of Budget

• Detroit Section
W. F. Sherman, Field Editor

April 18—"We are lousy engineers and economists if we can't exist on the prodigal supply of available energy," was one of the conclusions offered by **J. Carlton Ward, Jr.**, chairman of the Board, Fairchild Engine and Airplane Corp.

He was introduced to the audience by Prof. E. W. Conlon, University of Michigan, vice-chairman of the aeronautic activity for the Section.

Coordinated research and development is a very modern concept, carried on by groups of associated engineers and scientists (and accountants!) instead of by individuals, as earlier research was, he said. Germany in World War I convinced the world that such research paid off. Poor in natural resources, that nation actually built up a myth of superiority as a technical race.

American efforts had roots in the Academy of Sciences set up after the Civil War but not implemented very well until President Wilson called on it to establish a Research and Development Committee in 1916. Made permanent in 1918, it had the benefit of the directing efforts of such outstanding personalities as Thomas Edison.

Currently about $1 billion out of the military budget of $15.6 billion is directed at research and development. Continued expenditures in this direction are necessary, according to Ward. One of the practical reasons lies in the fact that airplane pilots are no longer able to fight while operating the machines which have outstripped the human element. Specifically, in a tenth of a second, while the pilot is "thinking one thought," the aircraft may travel a hundred feet. With guns firing 1200 shots per minute, bullets are 50 ft apart in space. Hence, intercepting and shooting down an enemy aircraft becomes a real problem. It is necessary to supplant man's biological senses with equipment that is faster and more accurate. Obviously, principles applied in this field will be applicable throughout our lives in peacetime, Ward commented.

St. Louis Sponsors Student Competition

• St. Louis Section
A. K. Miller, Field Editor

April 12—The student section at Parks College of Aeronautical Technology was the host to the St. Louis Section for the evening. After dinner in the

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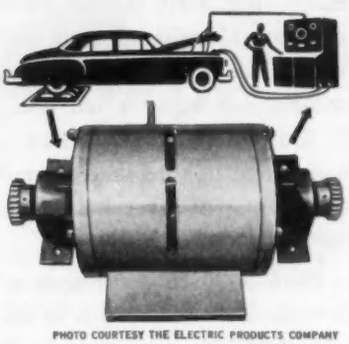

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cafeteria, the members were conducted by guides through the college. The college deals with all the characteristics of modern aviation mechanics, meteorology, business administration, and the operation of air lines.

The meeting convened in the college gymnasium to hear a series of five selected papers, delivered by students of the college. These papers were graded by Lloyd Novak of McDonnell Aircraft Co. for technical excellence, which counted as 70% of the total score, and for presentation, which counted 30%.

First prize of $15.00 was awarded to Bobby George Dudley for his paper "The Application of Jet Propulsion to Commercial Air Transport." Second prize of $10.00 was awarded to Clarence E. Youngman in collaboration with Stanley P. Yachnin for their paper "What America needs in a Commercial Airship." Third prize of $5.00 was awarded to Stephen L. Gugleta for his paper "Temperature and Metallurgical Problems in High-Speed Aircraft Design."

The other two papers, which were excellent also, were "The Cross Wind Landing Gear and its Problems" by Arad S. Peters and "A Student's Eye View of Water Injection" by Robert R. Shank.

The speakers were introduced by Niels C. Beck, dean of the college, and Gene Krops, head of the Air Transport Department. The meeting was in charge of Beck, who is vice-chairman for aircraft activities.

Wire Cost Delays Steel Cord Tires

• Hawaii Section
Rene Guillou, Field Editor

April 18—The steady progress toward lighter and stronger tire wall construction from the original cotton fabric tire through cords of cotton, rayon, and nylon to the current development of steel wires was described by **L. E. Copple**, Firestone Tire & Rubber Co.

Steel wire, already in commercial use in truck tires, was said to offer the possibility of a 2-ply passenger car tire stronger and more flexible than anything now on the market. High costs and scarcity of suitable wire are delaying this development, according to Copple.

It was pointed out that as compared with 1916 equipment, the modern passenger car tire is about double the size, carries half the pressure, and runs six times as far. The latest low-pressure tires are easier on the car and its passengers, provide better flotation on soft roads, and give better gasoline mileage than did their immediate predecessors.

This last feature, not generally appreciated by the public, is said to be due to superior flexibility of the tires, which reduces rolling resistance. On the other hand, these tires pose new problems for car designers because of increased steering effort required and by interfering with natural cooling of brake drums.

Off-the-road tires, with heavy walls for rough service at low speeds, were mentioned as of especial value for local plantation-field operations. The advantages of butyl tubes, cold rubber, and wide-base rims were described briefly. The movie "Building of a Tire" by Walt Disney and movies of historic incidents on the Indianapolis Speedway closed the program.

Economy Governs European Design

• Mohawk-Hudson Group
R. G. Shanklin, Field Editor

March 16—Real progress is being made in the rehabilitation of European automotive manufacturing plants in war-damaged areas, reported **George A. Round**, chief automotive engineer of the Socony Vacuum Oil Co., Inc.

Round has recently returned from a tour of England, Scotland, Sweden, France, and Italy, where he made extensive field trips to practically every automotive manufacturing plant.

The highlight of his talk was the detailed description of the engineering advances being made in automotive diesel design and construction. "Economy in operation is the motivating theme of all automotive engine design in Europe today," said Round.

Salient features of most of the British diesels and other foreign engines were illustrated by slides.

Tour Dramatizes Radiator Production

• Buffalo Section
Ben Fuente, Field Editor

April 26—After **Robert Morgan**, chief engineer of Fedders, Quigan Corp., previewed highlights of his company's plant, 80 members and guests toured the plant to see for themselves how automobile radiators are manufactured.

So interested were the visitors that the tour lasted until almost midnight.

Pres. Sparrow Speaks at Syracuse Section

• Syracuse Section
W. F. Burrows, Field Editor

April 29—Twin attractions at the section's ladies night were **SAE President S. W. Sparrow's** talk on "My Friend the Engine" and the University Players' "Trial by Jury" by Gilbert and Sullivan.

Sparrow pointed out that trial-and-error methods still play a vital part in design of a new engine.

Interrelates Fuel and Engine Design

• New England Section
A. R. Okuro, Field Editor

April 5—Much of the development in fuels and engines is due to the combined efforts of the petroleum and automotive industries, **Max M. Roensch** explained in his paper "Engine Design for Past, Present, and Future Fuels."

Roensch stressed how necessary it is for the two industries to work together, since the objectives of each group contribute to the major problem of producing products satisfactory to the customer. Roensch is research coordinator for the Ethyl Corp. and an SAE vice-president. He was introduced by Vice-Chairman Lewis P. Hankins.

Tracing trends from 1925, Roensch showed that passenger car engines' compression ratios have increased 50%, with approximately 100% gain in maximum brake horsepower and additional improvement in fuel economy. During these changes, only a small fluctuation in cubic displacement is noted. As compression ratios continue to become greater, higher anti-knock quality is required. At present it seems desirable to effect some change in engine design to moderate octane number requirements and to continue the search for a less costly method of producing gasoline with sufficient quality and octane number, he said.

Although the present-day engine is capable of greater output due to higher ratios and improved volumetric efficiency, factors such as time, temperatures, and pressures become more critical.

Progress has been made by modifying designs and materials to meet demands which have come from the research and study of parts and units under a variety of operating and test conditions, according to Roensch.

Adequate cooling and lubrication, valves and valve seats, piston design, chrome-plated rings in the top groove, rigidity and balance, freedom from wear and distortion were all mentioned by Roensch as factors to be considered in reducing costs of maintenance.

New Plane Designed to Operate in City

• New England Section

May 3—Successful flight tests on a revolutionary light plane which makes little more noise than an automobile and is capable of safe, everyday operation from a tiny strip of ground in the heart of a built-up area were described by **Prof. Lynn L. Bollinger.**

The craft has been named the Helioplane because its take-off and landing characteristics approach that of the helicopter, while in cruising speed, simplicity, and appearance it is similar to a conventional airplane. It was designed by Otto C. Koppen, professor of aeronautical engineering at Massachusetts Institute of Technology, to specifications laid out by Bollinger, who teaches at the Harvard Graduate School of Business Administration.

The first model of the plane, a two-passenger version, has made a number of flights, demonstrating ability to land and take off from an area no larger than a tennis court, Bollinger said. It is designed to clear a five-story structure only 100 yd from its starting point. It can fly at a minimum speed of 27 mph, with no risk of stalling or spinning. Yet its high-speed and load-carrying characteristics are comparable with those of an efficient modern plane of the same size. A high-wing monoplane, its appearance is similar to that of other private craft, he reported.

Discussers Differ with Wolf on Gearing

• Philadelphia Section
E. B. Eipper, Field Editor

April 13—**Austin M. Wolf** presented his Annual Meeting paper, "Means and Objectives in Multiratio Gearing," and his listeners responded with lively discussion.

Speaking as a designer of heavy trucks, Franklin R. Nail, executive engineer, Mack Manufacturing Co., Allentown, Pa., considered the two-speed axle and the duplex transmission to be competitive to a greater degree than did Wolf. Nail felt that properly engineered synchronizers have

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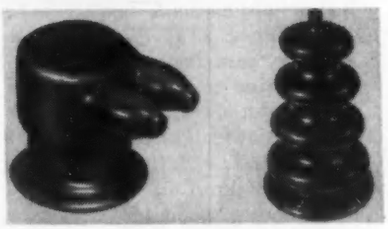

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a very important place in auxiliary transmissions, whereas the speaker did not. The need for more automatic controls on heavy transmissions was not accepted by Nail, who feels that driver skill must always be available for emergencies. He felt that drivers appreciate lessening of physical effort but want to be able to bring the equipment in on its own power even though there might be some minor failure.

The prepared discussion written from the transmission designer's viewpoint by W. P. Michell, chief development engineer, Spicer Manufacturing Co., Toledo, Ohio, was read by Andrew Leber of the Spicer Manufacturing Co. The ideals laid down by Wolf will be approached more closely as a result of present planning and testing, but at the moment the 4 x 3 combination with even cube-root splits is doing the best job in long distance highway work, according to this discussion.

The viewpoint of a two-speed axle designer was reflected in the discussion presented by Harry H. Hooker, asst. chief engineer, Eaton Manufacturing Co., Cleveland Ohio: The unsprung weight penalty of a typical light-truck two-speed axle is 6.5% of the weight of the single-speed axle, but the torque capacity is greater to permit the customary use of the two-speed axle in more severe service. The use of a power shift with the control mounted on the transmission shift lever permits making quiet axle shifts in 1/5 to 2/5 sec whereas quiet transmission shifts require over 1 sec.

Hooker stated that diesel-engine-powered trucks with two-speed axles have given very satisfactory performance, whereas Wolf had stated that the combination of a two-speed axle and a diesel engine might be undesirable.

B. Frank Jones, chief engineer of the Autocar Co., presided.

Frameless Car

Cont. from p. 72

perience and costs of repairs on Nash cars, developed by leading insurance companies, were comparable to that of other makes. Certain adjusters report that, since no frame straightening is required on unitized bodies, repairs can be made through sectional replacements or replacement of a portion of a section.

In many cases the cost of repairs of a Nash unitized body is less than for a conventional car with similar damage. (Paper "Design of Frameless Car Body Structure and its Relation to Service," was presented at SAE National Passenger Car, Body, and Production Meeting, Detroit, March 9, 1949. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to non-members.)

New Members Qualified

These applicants qualified for admission to the Society between April 10, 1949 and May 10, 1949. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (Aff.) Affiliate; (SM) Service Member; (FM) Foreign Member.

Baltimore Section

Richard L. Ashley (A), George LeRoy Coleman (M), George R. Helwege (J), David H. Specht (J).

British Columbia Group

James Alexander Angus (J), Kenneth Murdoch Wilson (A).

Buffalo Section

Raymond A. Lander, Jr. (M).

Canadian Section

Richard Lee Cribb (A), Clifford F. Graham (M), Robert Thomas Hazell (A), David Keith Jackson (J), Ivan S. Kaye (M), William L. D. Muir (A), William Rowe (A).

Central Illinois Section

Max M. Gilbert (A).

Chicago Section

Earle F. Clegg (A), Paul G. Fricke (A), E. S. Kavanaugh (M), Robert Arthur Klee (J), George Matthews (M), Morris J. Rowlands (J), Irving R. Ruby (A), Robert A. Shogren (J), Frederick S. Wood (M).

Cleveland Section

D. S. Kimball, Jr. (M), Frank B. Parsson (A), Henry Alfred Peller (M).

Dayton Section

Daniel Walther (J).

Detroit Section

Dominic Badalamente (J), Frank Baird-Smith (M), Henry LeRoy Byerlay (M), Harvey Thomas Dickinson (J), Clyde E. Evenson (A), F. Howard Grady (M), Gilbert K. Hause (M), H. Douglas Lange (M), Howard Vincent Lindbergh (M), Fred G. Loon (M), Wendell Gage Loveless (J), Benjamin A. Main, Jr. (M), Richard M. Nielsen (A), Cornelius F. O'Shea (M), C. E. Patterson (M), William D. Pittsley (J),

Edward Harold Protz (M), Frank Harwood Riddle (M), William Robert Smith (J), Harold Stipcich (J), Harold G. Stringer (A), Murray C. Triplett (J), Clarence E. Wittmer (M).

Hawaii Section

Philip E. Chase (A).

Indiana Section

A. A. Catlin (M), Joe V. Gaebler (M).

Kansas City Section

Donald Martin Crowley (J), Joseph Edgar Storment (M).

Metropolitan Section

William R. Beckerle (J), Alfred Del Vecchio (J), Kachas Derdiarian (J), L. A. Douglass (A), Miss Selma G. Gottlieb (J), Samuel H. Grossman (A), James J. P. Mac-Veigh (M), Sol Silverman (J), Nathan Winarsky (A).

Mid-Continent Section

Fred Champlin (A), Robert O. Gose (J), George Dayton Kittredge (J).

Milwaukee Section

Charles Nash Miller (M).

New England Section

J. Conrad Johnson (A), William J. Keefe (M), Harold D. Kelsey (M), Sacit Abdullah Sumer (J).

Northern California Section

F. T. Brown (A), Robert L. Carpenter (A), Howard Orrin Gaston (A), Henry W. Larson (A), Alexander Claude MacKenzie (M), B. C. Mills (A).

Northwest Section

Marvin L. Johnson (A).

Oregon Section

Harry D. Smith (A).

Philadelphia Section

Herbert Klossner Livingston (M), Paul J. Seng (M).

Pittsburgh Section

J. Dick Blackburn (A), Harry R. Breniser (A), Joseph N. Kellerman (A).

St. Louis Section

T. V. Picraux (A).

Salt Lake Group

W. P. Ackerman (A), Eugene C. Rollins (M).

Southern California Section

Frank W. Hodgdon, III (J).

Southern New England Section

Oscar G. Knapp (A), Lewis C. Stone (M).

Virginia Section

Emerson L. Thomas (A).

Washington Section

Russell C. Mazer (M).

Western Michigan Section

Maurice W. Bolster (A), Robert W. Emelander (J).

Outside of Section Territory

Gardner J. Fabian (M), Karl W. Galliger (M), Carleton F. Maylott (M), Douglas A. Philbrook (A), William B. Ranck (J), Byron Tellander (M), R. C. Zeller (M).

Foreign

2nd Lt. Rogerio Nogueira daSilva Rego (J), Brazil; Karl Stief (FM), Germany.

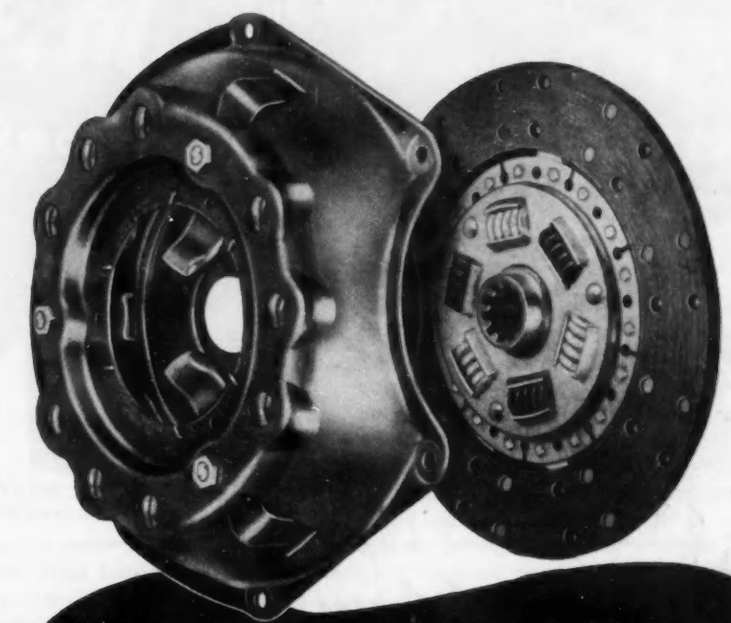
Applications Received

The applications for membership received between April 10, 1949, and May 10, 1949 are listed below.

British Columbia Group

Harry Robert Borrie, Henry Paul Grone, Ernest A. Middleton.

Buffalo Section



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Canadian Section

J. Armand Bombardier, Herschell Buck, Major C. N. Carscallen, Frank J. Crothers, Fred Russell Hazelton, Fred Holmes Hopkins, Albert (Bert) Edward Jagger, John Wilson Jolly, Albert Edward Lewis, Reginald Lyle Miller, William H. Wright.

Central Illinois Section

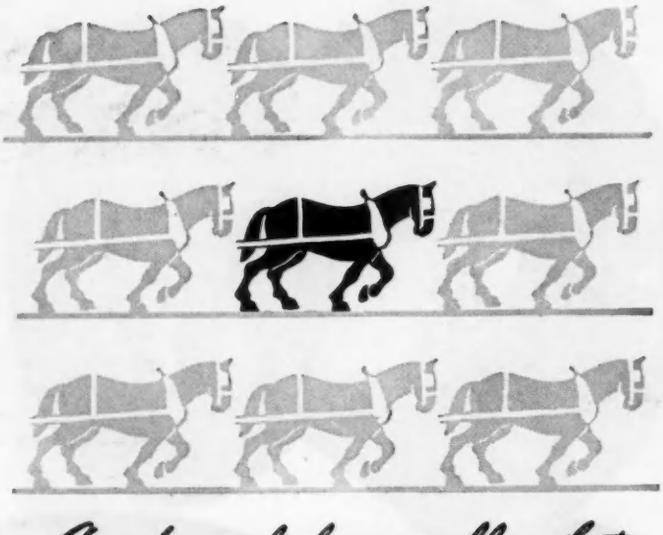
Harvey M. Sibrel.

Chicago Section

Hilton H. Applegate, Emmett A. Busse, Arthur C. Cox, Lee D. Evans, S. I. MacDuff, Stanley Frank Novak, John Ronald Ross, Simon Ruttenberg, R. A. Schafer, Robert L. Shallenberg, R. W. Spencer, James S. Sutherland, James Russell Tutt, Raymond S. Vicker, Boyd A. Whitehead, Edgar D. Wilborn.

Cincinnati Section

Merton B. Briggs, Jack P. Pedersen.



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Dayton Section

Vernon A. Smith.

Detroit Section

Clare P. Briggs, John S. Conant, Charles M. Daniels, Jr., John T. Gallatin, Leonard J. Granke, H. H. Handorf, Carl J. Hiehle, John F. Jordan, George Kalon, Richard D. Kelly, Richard H. Lloyd, Witold Malecki, Robert Verland McCallister, Jack Newlove, Alfred D. Slatkin, George Paul Vest, Henry O. Wagner, Edmund J. Zeglen.

Indiana Section

D. J. Cummins, Philip H. Sanders.

Kansas City Section

Jack F. Whitaker.

Metropolitan Section

Hugo V. Giannotti, George J. Glaser, Stephen Richard Nemeth, H. Norman Nugent, Paul Slysh.

Milwaukee Section

David Frank Cosgrove, Edward W. Borchert, Charles E. Heitman, Jr., Donald H. Dechant, Alfred William Schaper.

New England Section

James Henry Hartwell, Draper Moulton Harvey, Thomas J. Lavin, J. Alexander Michaud, John E. Sterling.

Northern California Section

Joseph Y. Chinn, John L. Cooley, Leon A. Cornett, Carl B. Engstrom, Donald T. Green, Allen Carl Haase, C. H. Wiget.

Northwest Section

Charles Atherton, Dean S. Kasper.

Oregon Section

G. Douglas Hood, Daniel O. Thornton.

Philadelphia Section

Arnold D. Cohen, Frederick Tinsdale Cushing, L. Eric Jones, Charles Stauffer Keller, Frank P. Watson.

Pittsburgh Section

Thomas Stewart Creighton, William C. Offutt, R. N. Scott.

Southern California Section

Jack J. Cimo, P. N. Fitzgerald, John Stanley Keenan, Frank Mayer, Frank W. Murphy, Rev. Frank Joseph Weber, George Harry Windsor.

Virginia Section

James H. Lumpkin, Jr., John Clayton Turpin, Michael W. West.

Williamsport Group

George V. Hoover.

Outside of Section Territory

Benjamin Nicol Ashton, Robert Lewis

Ednie, Jack M. Smith, John Louis Wantland, Robert James Woolf.

Foreign

Frederick Edward Stanford Hudspeth, England; John Glyn Jones, Africa; C. H. Latimer-Needham, England; Karl Erik Lindkvist, Sweden; Mugada Surya Prakasa Rao, India; Victor Gerald Young, England; Kenneth Alban Wright, England.

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Central Illinois

K. J. Fleck, Caterpillar Tractor Co., Peoria, Ill.

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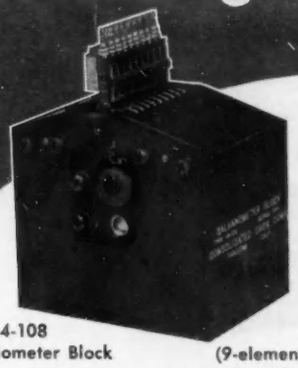

Type 14-108 Galvanometer Block (9-element)

*FIGURE OF MERIT
(*Sensitivity* x *Resonant Frequency*^{2})

IN THE FIELD of Recording Galvanometers the primary desire is to have maximum sensitivity over a maximum frequency range. To provide a comparative rating by which all makes of galvanometers may be judged, Consolidated Engineering has set up a Figure of Merit, with sensitivity and frequency range the prime criteria.

Galvanometer sensitivity varies inversely as the square of the resonant frequency, other factors remaining constant, and both are determined by the design and construction of the instrument. The Figure of Merit is then determined by multiplying the Sensitivity (in millimeters per microampere per meter) by the Resonant Frequency (in cycles per second) squared, $FM = SF_r^2$. This Figure of Merit is based on current sensitivity.

Consolidated Galvanometers, long the accepted standard in many industries and governmental agencies, rate a high Figure of Merit in all types and models. We are proud of this rating—a rating brought about through experience, know-how, and expert craftsmanship.

The wide range of frequencies and sensitivities offered in the two series of Consolidated Galvanometers furnishes 20 individual instruments to choose from to best fit your needs. The 7-100 Series are 4.5 inches long and 0.24 inches in diameter. The 7-200 Series are 2.75 inches long by 0.1625 inches by 0.1825 inches, the smallest commercial galvanometer available. Both of these series are produced in frequencies up to 2000 cps. Magnet Blocks are available for mounting galvanometers in various numbers up to 36.

The quality and accuracy of Consolidated Galvanometers have played an important role in Consolidated's leadership in the design and manufacture of Recording Oscillographs.

An informative 12-page bulletin on Recording Galvanometers has been prepared by Consolidated and is available, without charge, by writing for Bulletin CEC-1501-X2.

For information on Consolidated Recording Oscillographs, write for Bulletin CEC—1500—X6.

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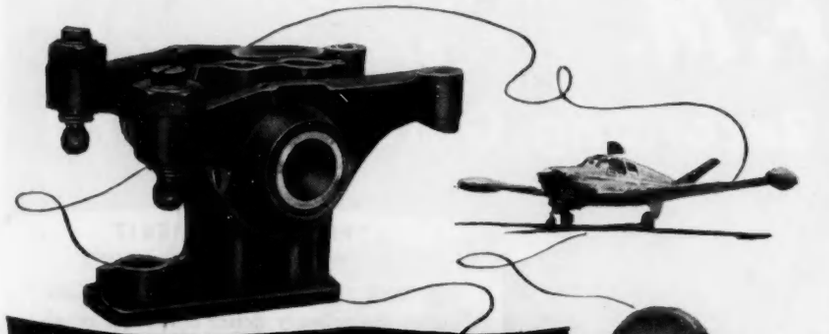

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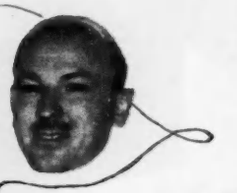

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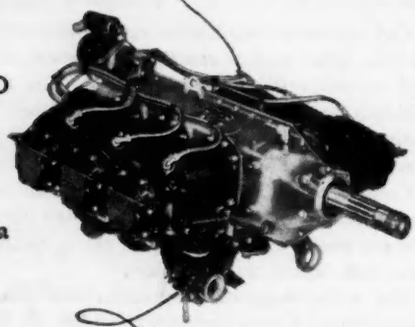

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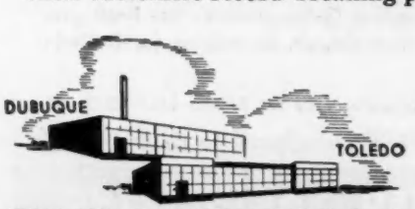

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